LUMIP paper plan: SOC and LUC

Project Title: Pasture in the global water and carbon cycles and its climatic feedbacks

Project participants: Akihiko Ito (NIES: itoh@nies.go.jp), Tomohiro Hajima (JAMSTEC), et al.

LUMIP / CMIP6 simulations used: LUMIP/SCENARIOMIP land-hist, land-noLu, land-noPasture, land-crop-grass

Brief Project Description: Pasture, or managed grassland, covers about one-third of land surface and so plays considerable roles in the global water and carbon cycles. However, ESMs and terrestrial models differ widely in parameterization of pasture processes including human management. This project focuses on the roles of pasture under historical land-use change and evaluates its climatic feedbacks, carrying implications on desirable management of pastures. Additionally, parameterizations of pasture in LUMIP models are compared.

Project Title: Impacts of historical and projected land-use change on global soil C stock

Project participants: Akihiko Ito (NIES: itoh@nies.go.jp), Tomohiro Hajima (JAMSTEC), et al.

LUMIP / CMIP6 simulations used: LUMIP/SCENARIOMIP land-hist, land-noLU, ssp* and esm-ssp*

Brief Project Description: Land-use conversion has long-lasting impacts on soil organic carbon, which is one of the largest carbon pools at decadal time scale. This project focuses on the effects of land-use change on soil organic carbon pools in the context of 4/1000 initiative proposed at the COP21. Specifically, we would like to assess global soil carbon stock, its temporal change through the past to the future, under different land-use and climate scenarios.

LUMIP paper plan: SOC and LUC

Title (preliminary): Future soil carbon sequestration under climate and land-use change toward achieving the 4/1000 initiative: an assessment using CMIP6-LUMIP outputs

Overarching question

• Can we mitigate global warming by use of soil functions?
    => soil as CDR and NETs

Associated questions

• How much carbon will be fixed into or released from soil under the CMIP6 land-use and climate scenarios?

• How much effort (i.e. land management, technology, cost etc.) is required to achieve the 4/1000 initiative?

Contribution to LUMIP

• Analysis of soil-related variables in LUMIP and other MIPs (e.g., C4MIP and ScenarioMIP) in terms of time-series and spatial distribution

• Inter-sectoral analysis with food, water, etc.

LUMIP paper plan: SOC and LUC

Geoderma 292 (2017) 59–86

Contents lists available at ScienceDirect

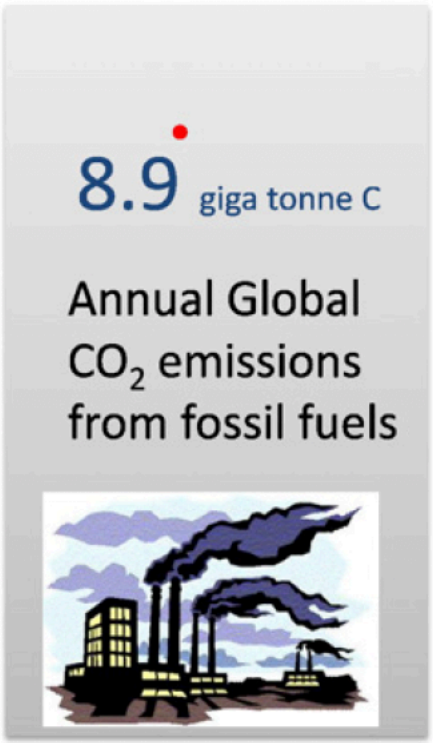
Geoderma

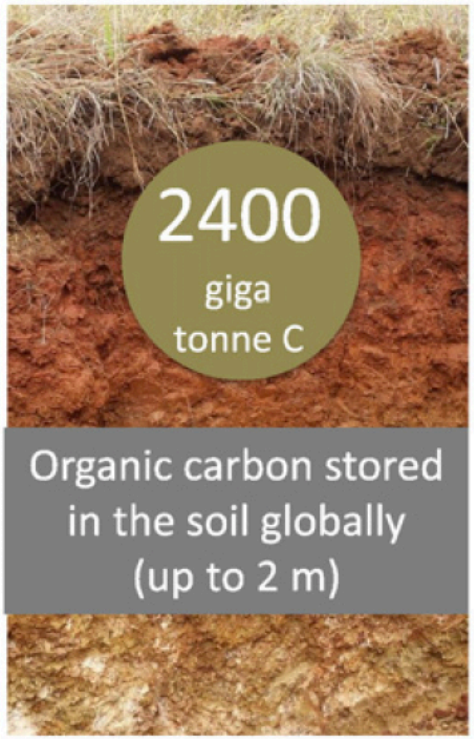
journal homepage: www.elsevier.com/locate/geoderma

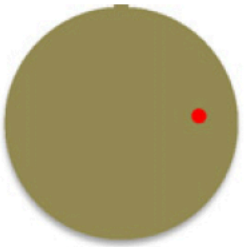
Soil carbon 4 per mille

Budiman Minasny [a,*], Brendan P. Malone [a], Alex B. McBratney [a], Denis A. Angers [b], Dominique Arrouays [c], Adam Chambers [d], Vincent Chaplot [e], Zueng-Sang Chen [f], Kun Cheng [g], Bhabani S. Das [h], Damien J. Field [a], Alessandro Gimona [i], Carolyn B. Hedley [j], Suk Young Hong [k], Biswapati Mandal [l], Ben P. Marchant [m], Manuel Martin [c], Brian G. McConkey [b], Vera Leatitia Mulder [n], Sharon O'Rourke [o], Anne C. Richer-de-Forges [c], Inakwu Odeh [a], José Padarian [a], Keith Paustian [p], Genxing Pan [g], Laura Poggio [i], Igor Savin [q], Vladimir Stolbovoy [r], Uta Stockmann [a], Yiyi Sulaeman [s], Chun-Chih Tsui [f], Tor-Gunnar Vågen [t], Bas van Wesemael [u], Leigh Winowiecki [t]

What is 4/1000 initiative?
(proposed at COP21)



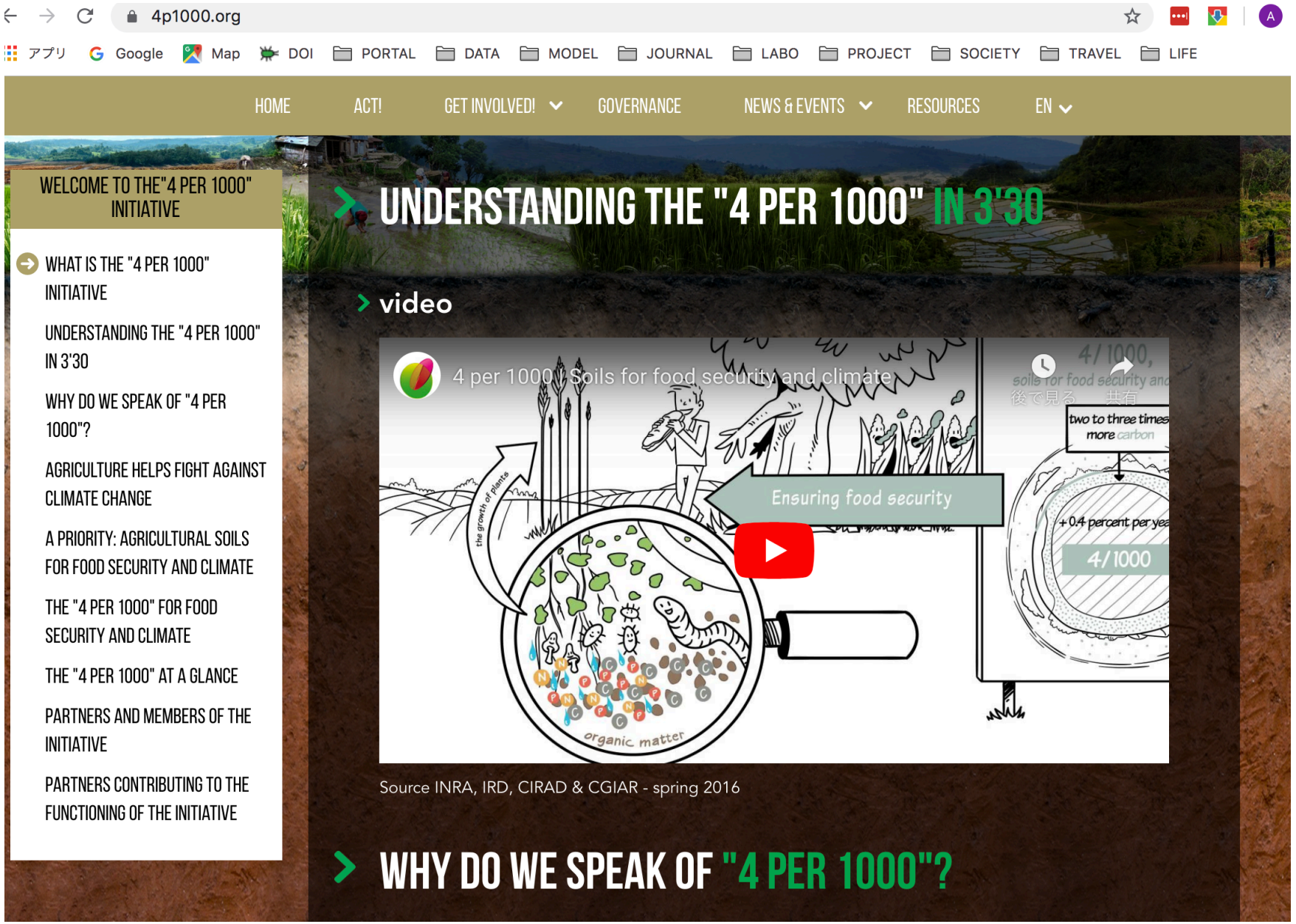




$8.9 / 2400 = 4‰$

Amount of
C stock
increase
needed to
offset CO_2
emission

LUMIP paper plan: SOC and LUC



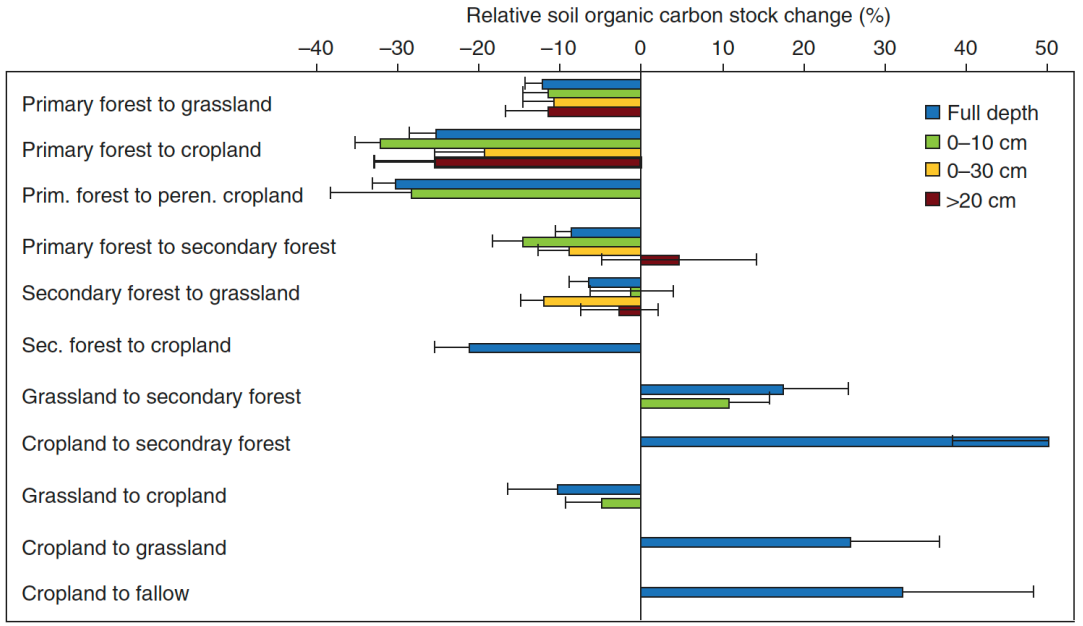
LUMIP paper plan: SOC and LUC

Global Change Biology (2011) **17**, 1658–1670, doi: 10.1111/j.1365-2486.2010.02336.x

REVIEW

Impact of tropical land-use change on soil organic carbon stocks – a meta-analysis

AXEL DON*, JENS SCHUMACHER† and ANNETTE FREIBAUER*

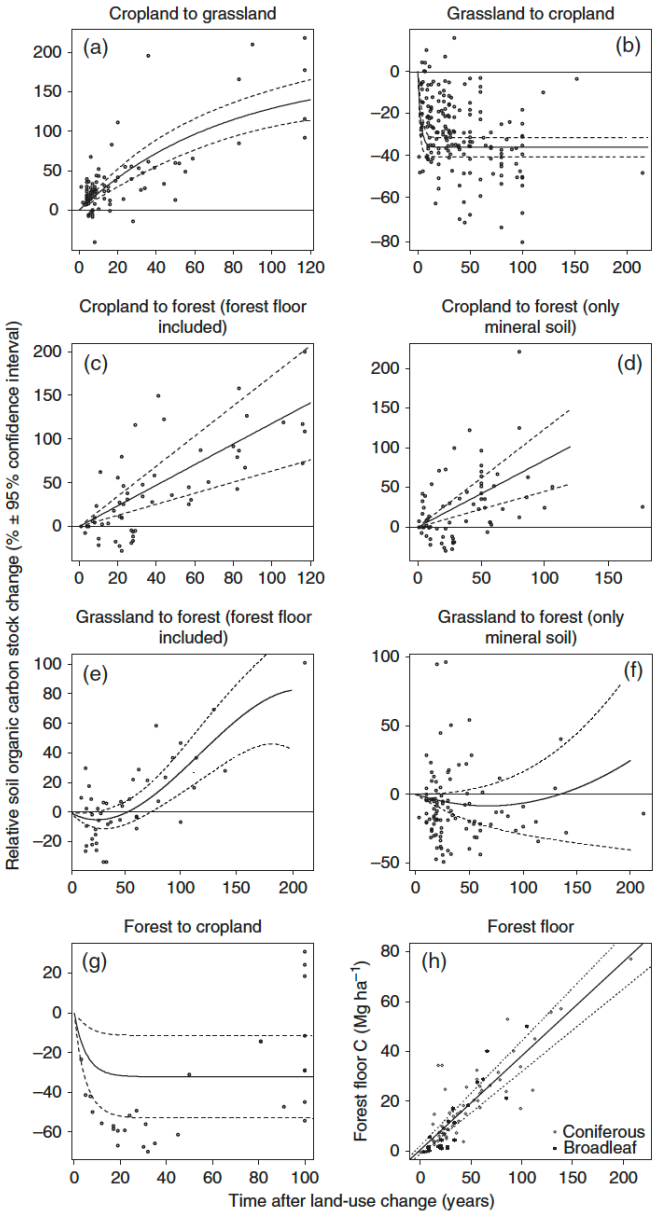


Global Change Biology (2011) **17**, 2415–2427, doi: 10.1111/j.1365-2486.2011.02408.x

REVIEW

Temporal dynamics of soil organic carbon after land-use change in the temperate zone – carbon response functions as a model approach

CHRISTOPHER POEPLAU*, AXEL DON*, LARS VESTERDAL†, JENS LEIFELD‡, BAS VAN WESEMAEL§, JENS SCHUMACHER¶ and ANDREAS GENSIOR*



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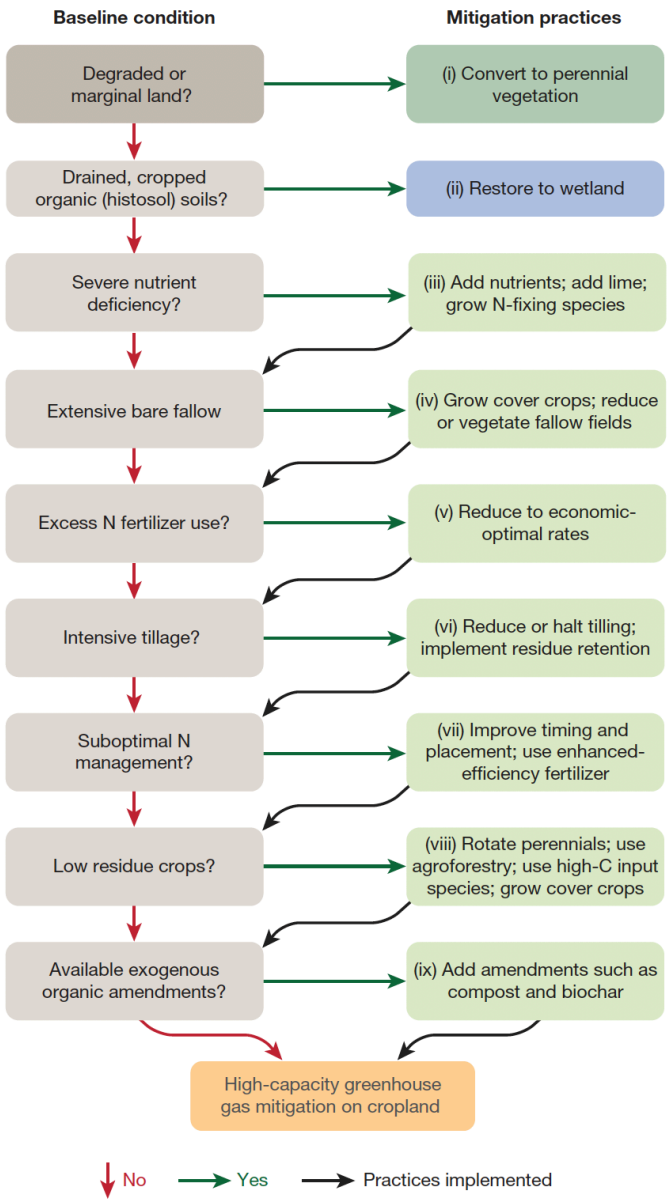


How can we increase soil carbon by management?


PERSPECTIVE

doi:10.1038/nature17174

Climate-smart soils

Keith Paustian[1,2], Johannes Lehmann[3], Stephen Ogle[2,4], David Reay[5], G. Philip Robertson[6] & Pete Smith[7]

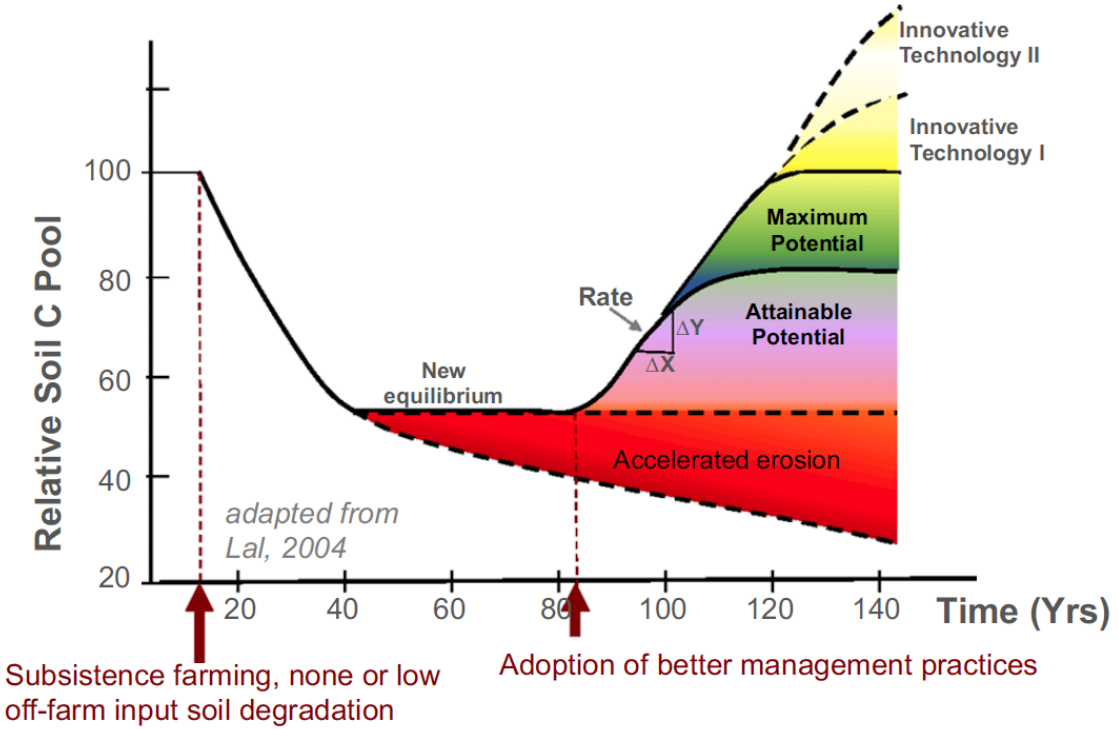
Ambio
https://doi.org/10.1007/s13280-019-01165-2

KUNGL VETENSKAPS AKADEMIEN

PERSPECTIVE

The 4p1000 initiative: Opportunities, limitations and challenges for implementing soil organic carbon sequestration as a sustainable development strategy

Cornelia Rumpel, Farshad Amiraslani, Claire Chenu, Magaly Garcia Cardenas, Martin Kaonga, Lydie-Stella Koutika, Jagdish Ladha, Beata Madari, Yasuhito Shirato, Pete Smith, Brahim Soudi, Jean-François Soussana, David Whitehead, Eva Wollenberg



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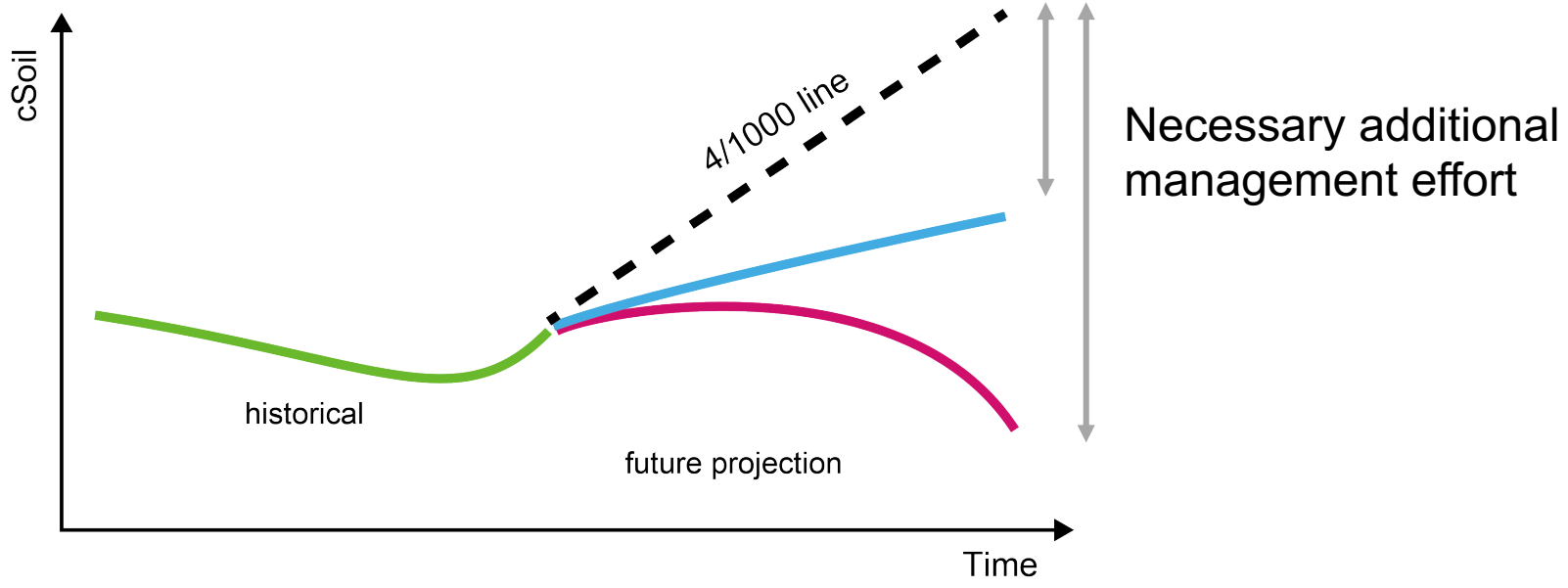
Models (as of Sep. 2019)

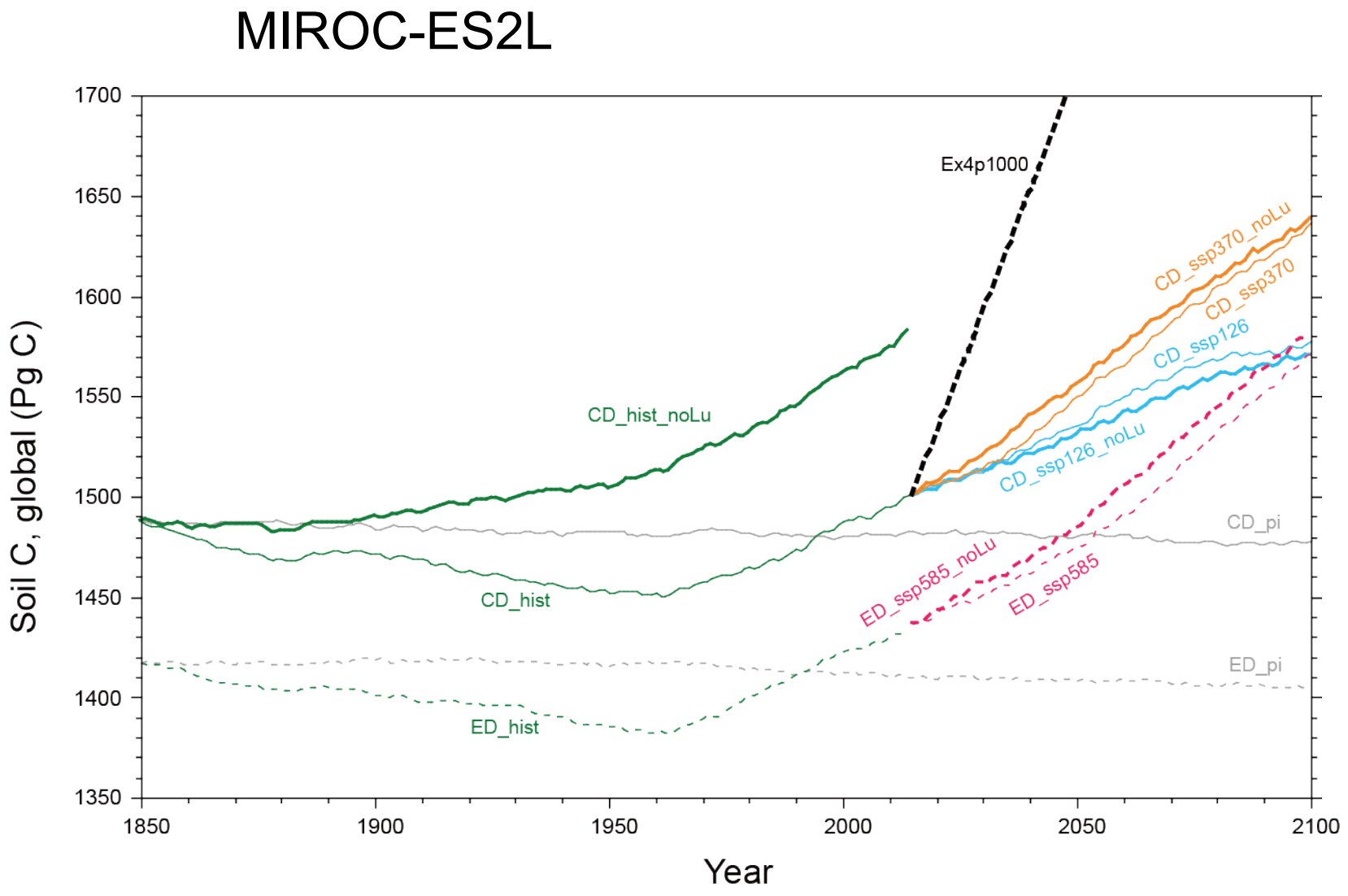
model	# of experiments	deforest-globe	esm-ssp585-ssp126Lu	hist-noLu	land-cCO2	land-cClim	land-crop-noFert	land-hist	land-hist-altStartYear	land-noFire	land-noLu	ssp126-ssp370Lu	ssp370-ssp126Lu
# of models	31	5	3	4	1	1	1	5	1	1	2	3	4
BCC-CSM2-MR	7	156	157	157				41			41	151	155
CESM2	11	370	179	1298	172	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

+ MIROC-ES2L

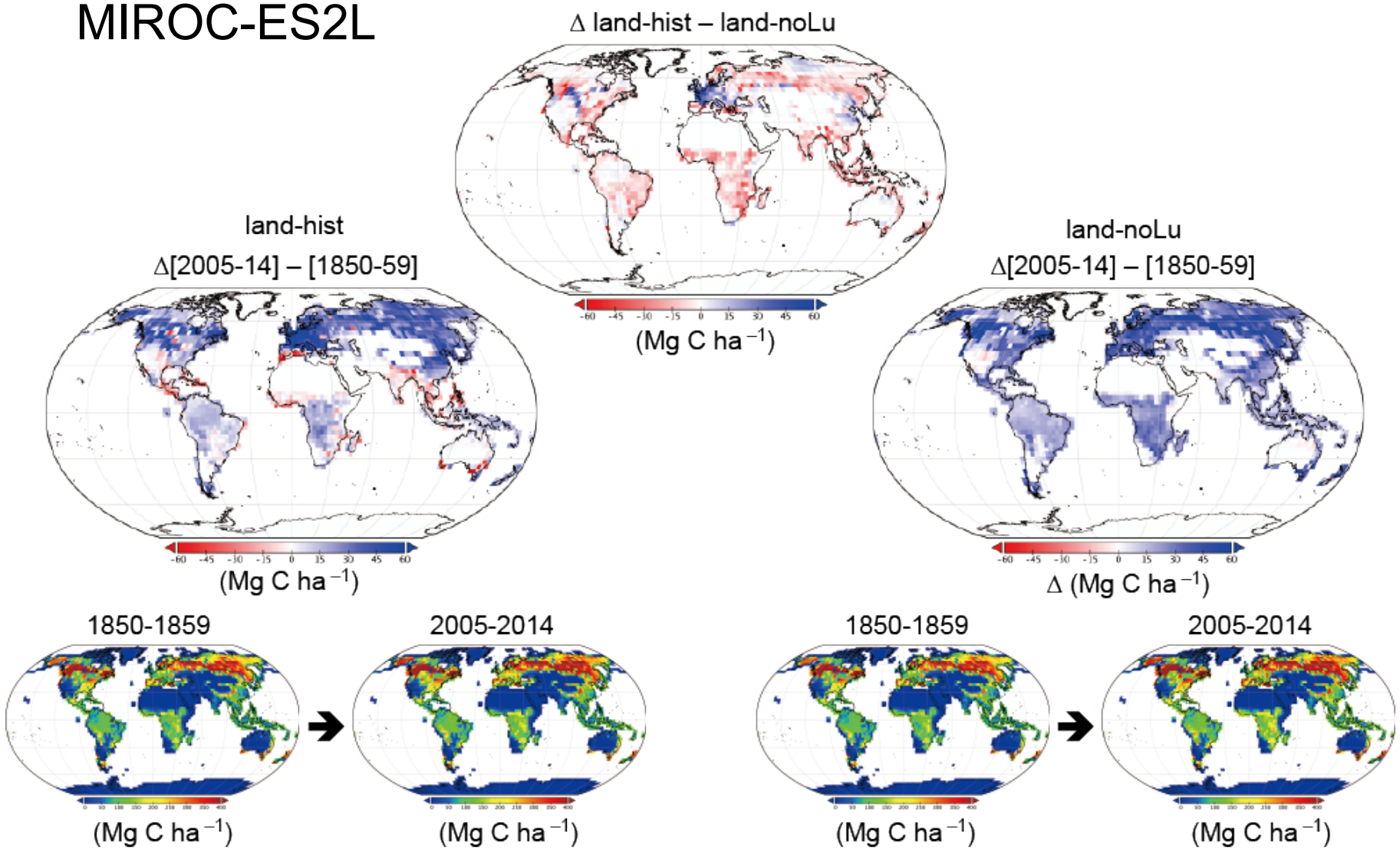
Variables: cSoil (additional variables will be included)



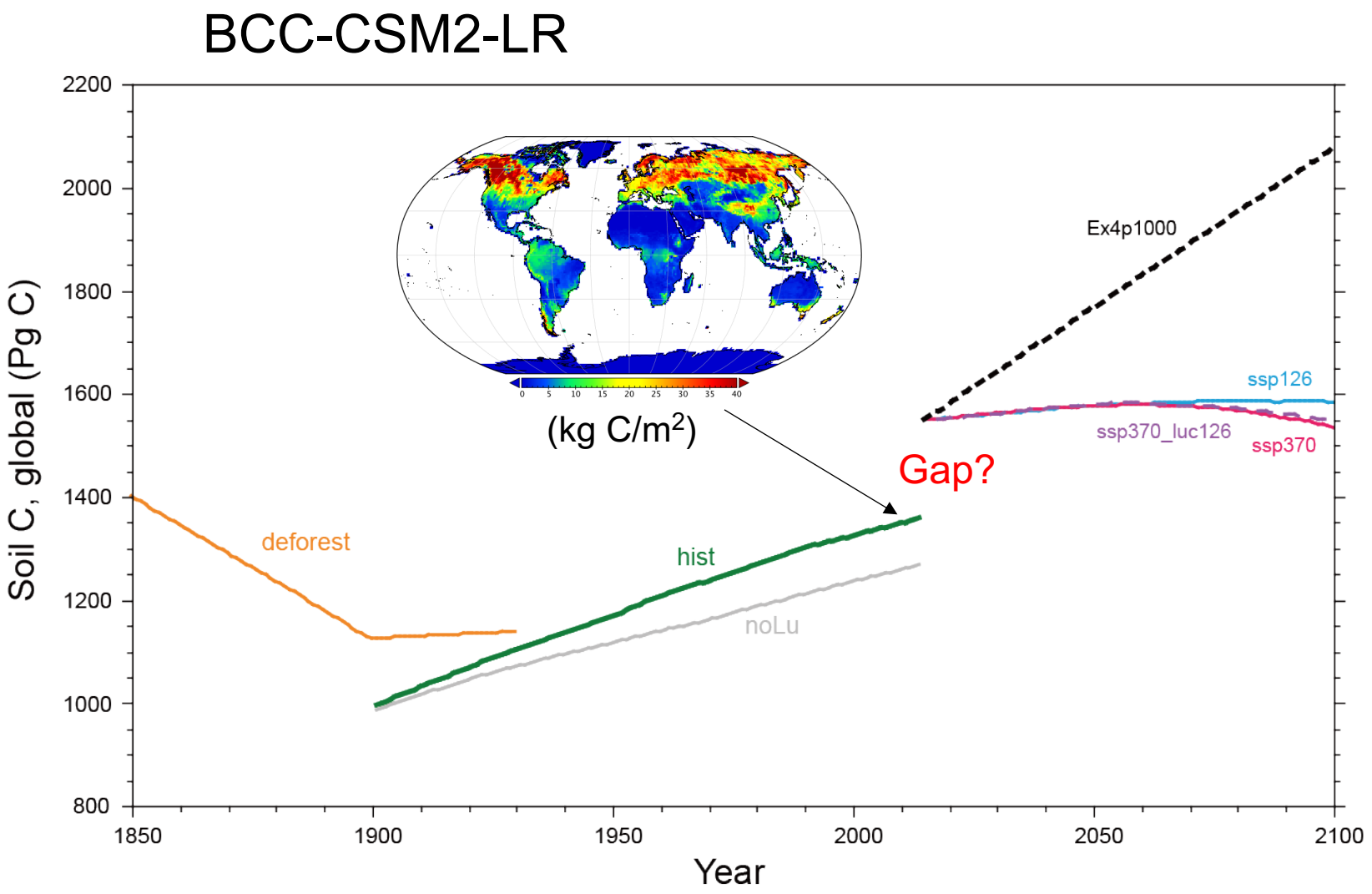
LUMIP paper plan: SOC and LUC



LUMIP paper plan: SOC and LUC

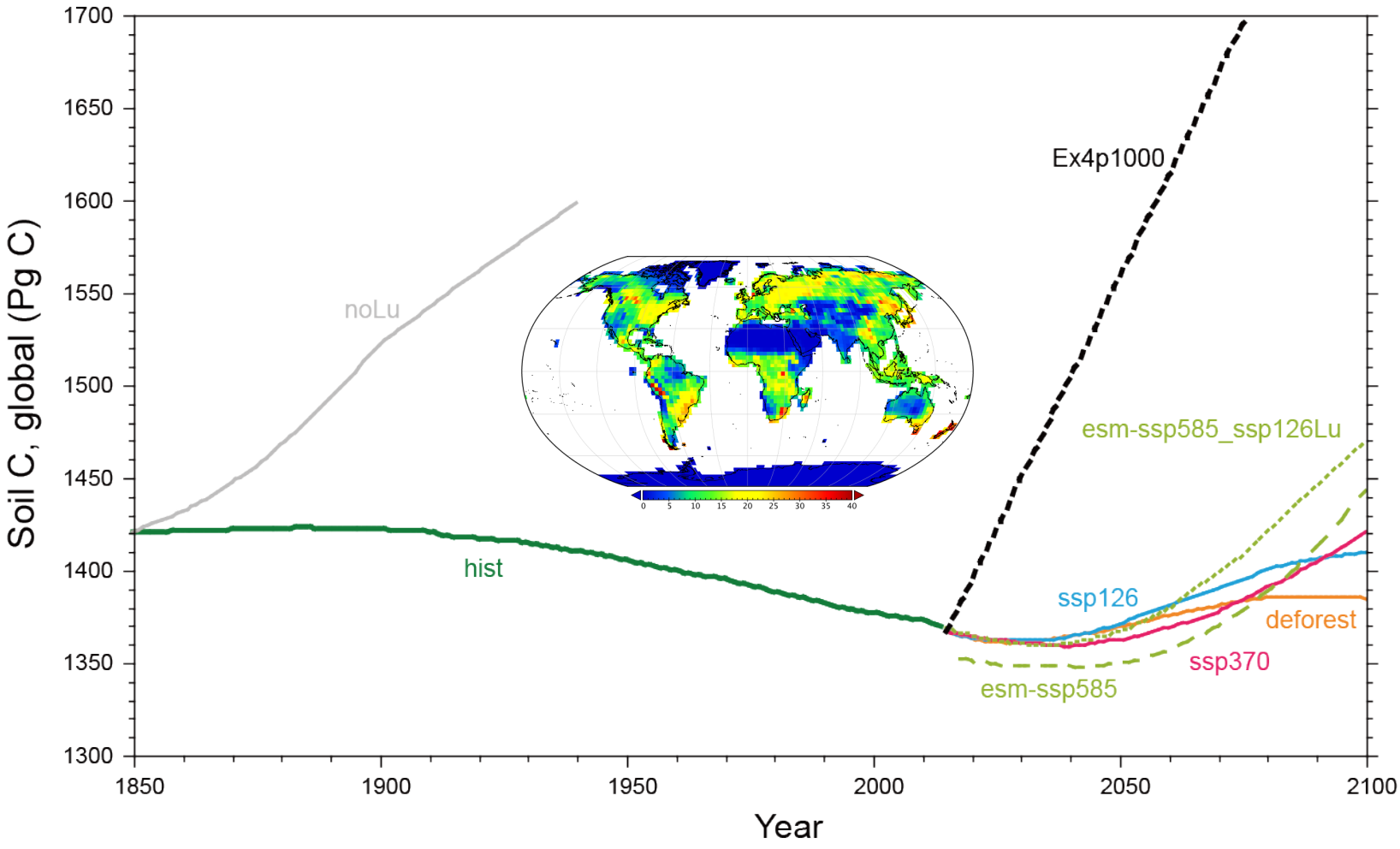


LUMIP paper plan: SOC and LUC



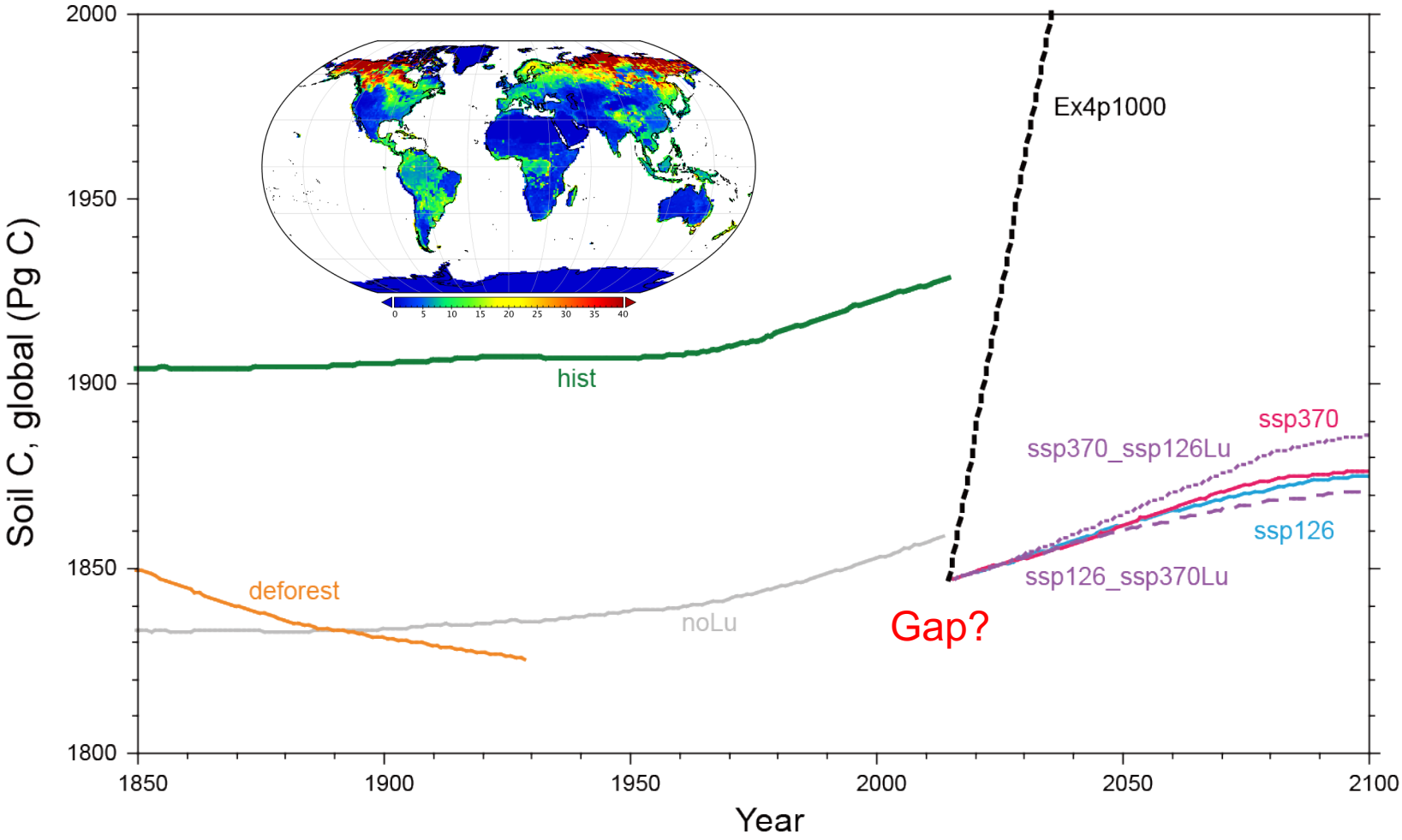
LUMIP paper plan: SOC and LUC

CanESM5

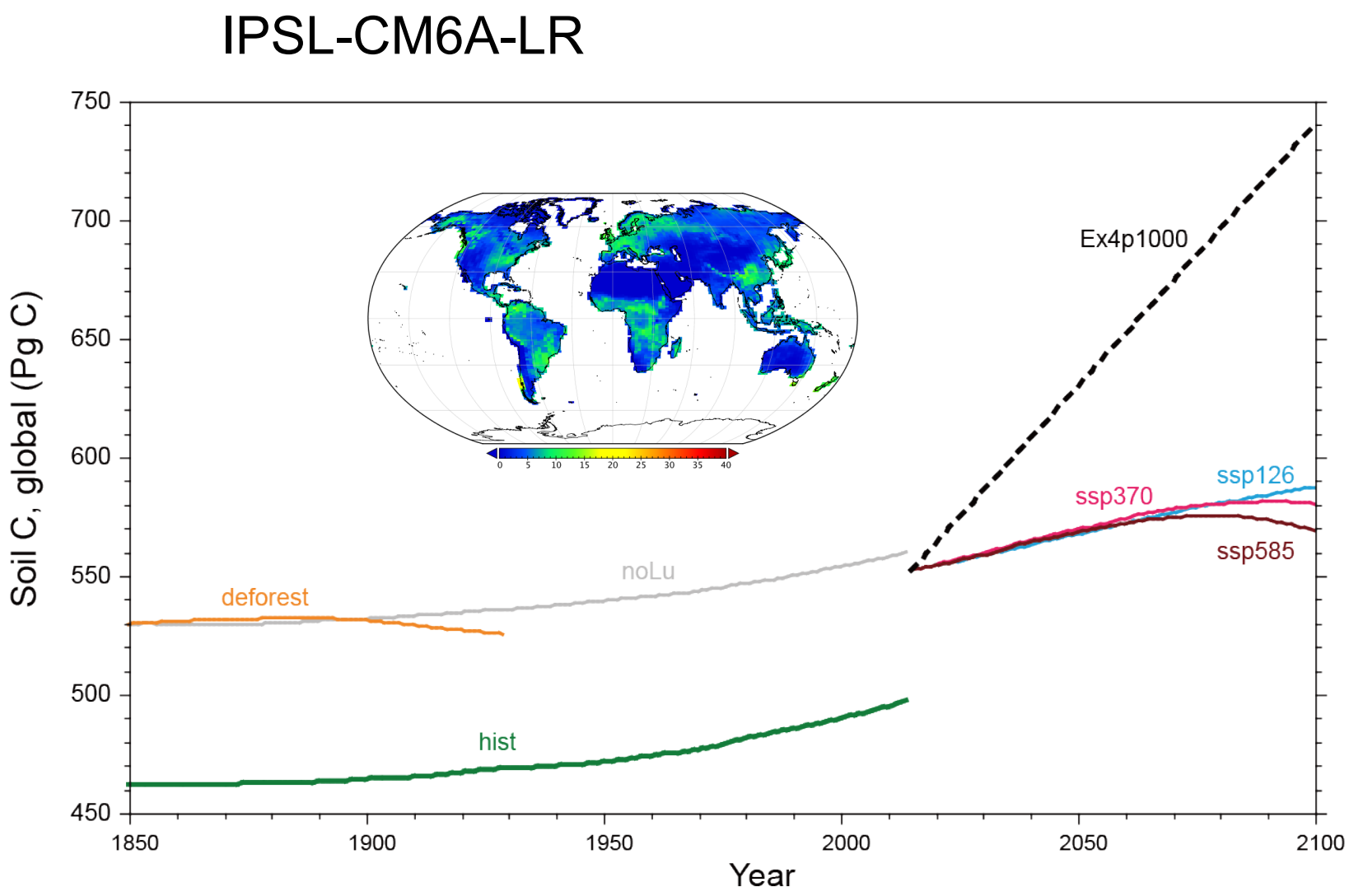


LUMIP paper plan: SOC and LUC

CESM2



LUMIP paper plan: SOC and LUC



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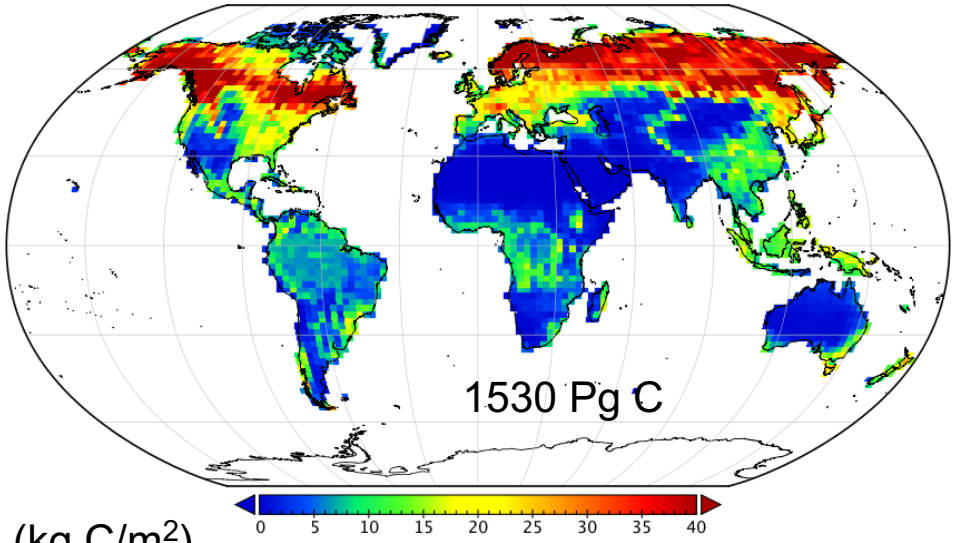
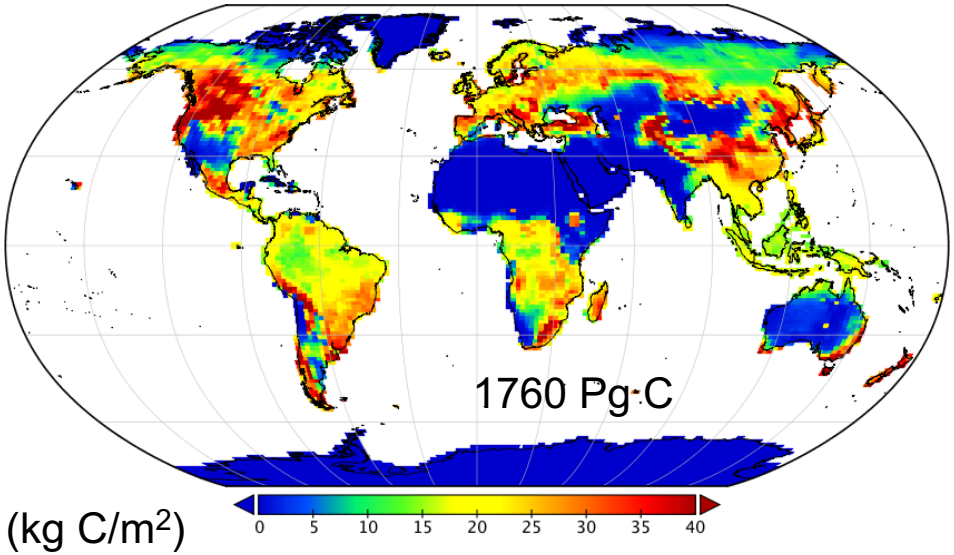
GISS-E2-1-G



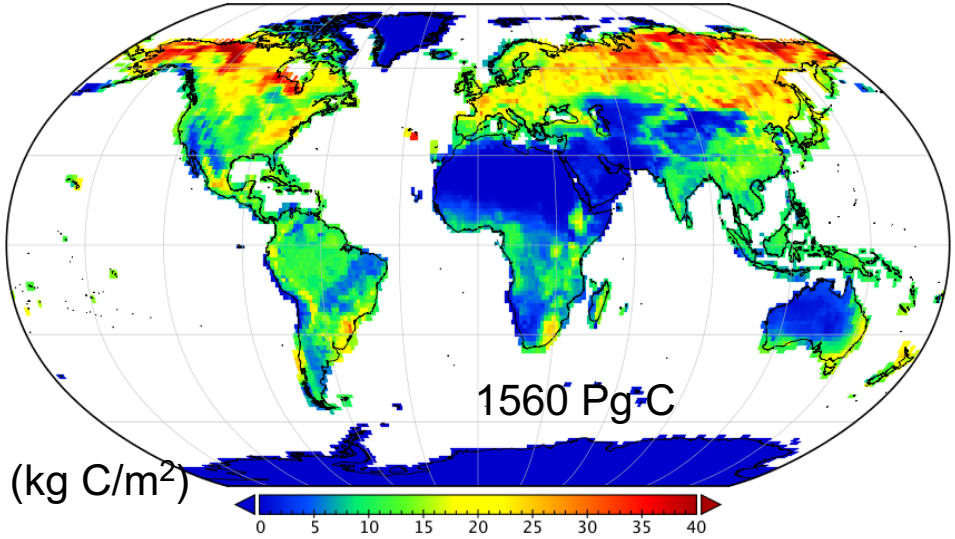
(kg C/m^2)

UKESM1-0-LL



(kg C/m^2)

CNRM-ESM2-1

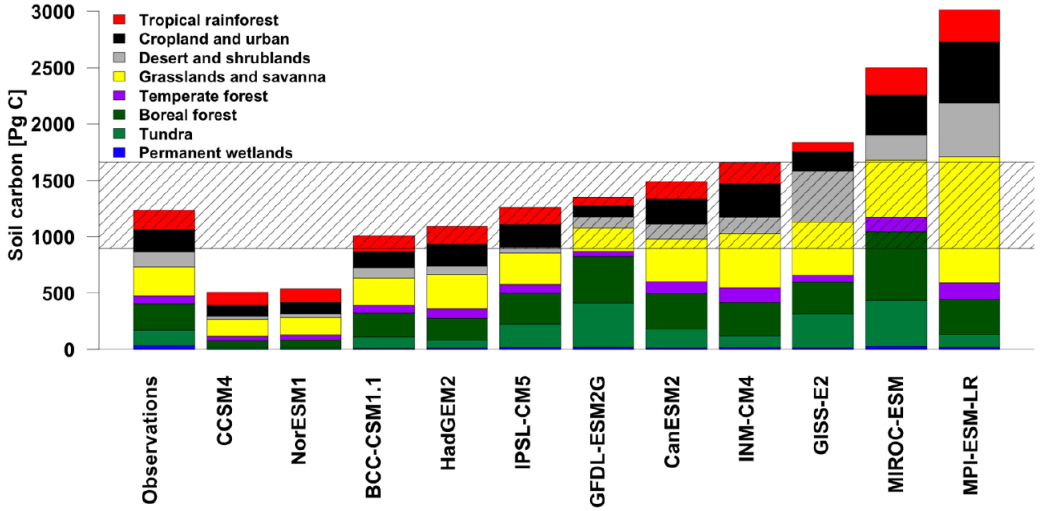


(kg C/m^2)

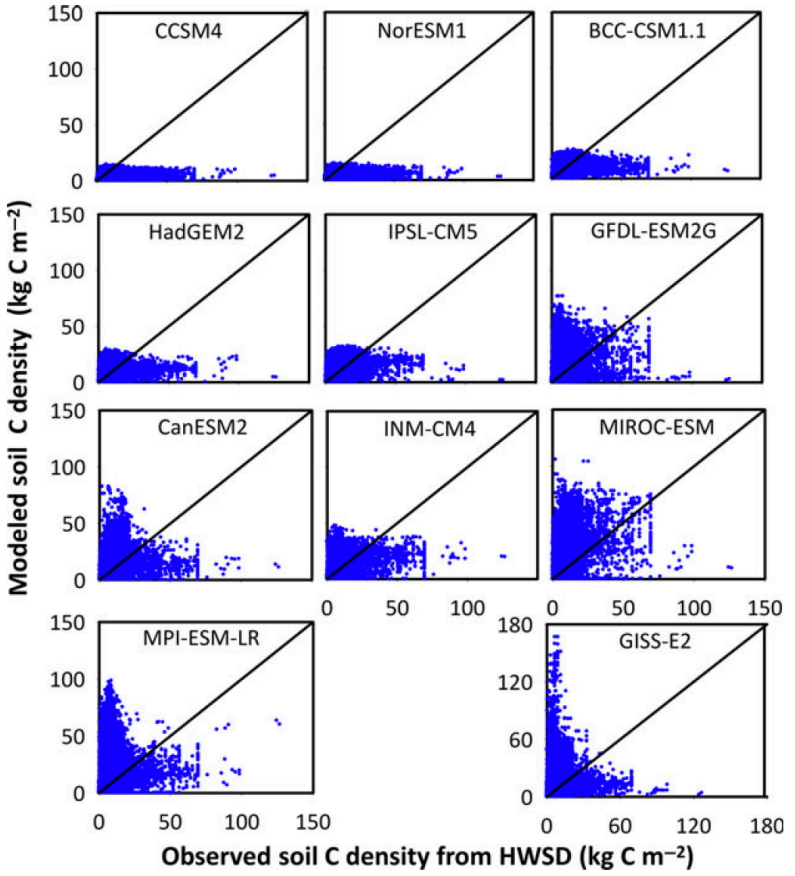
LUMIP paper plan: SOC and LUC

SOC uncertainty in CMIP5 models

Todd-Brown et al. (2013)

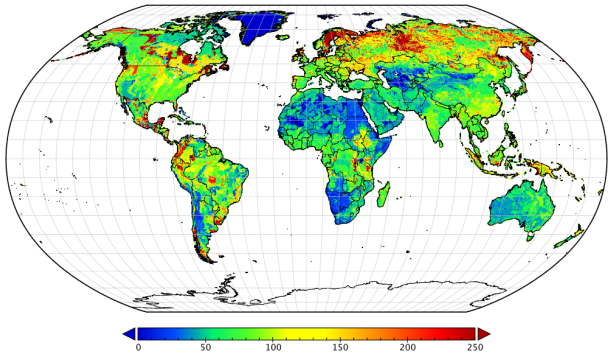


Luo et al. (2015)

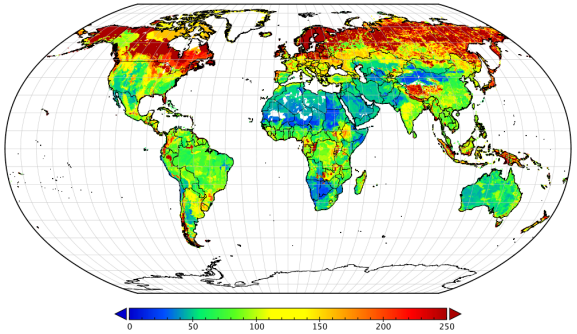


LUMIP paper plan: SOC and LUC

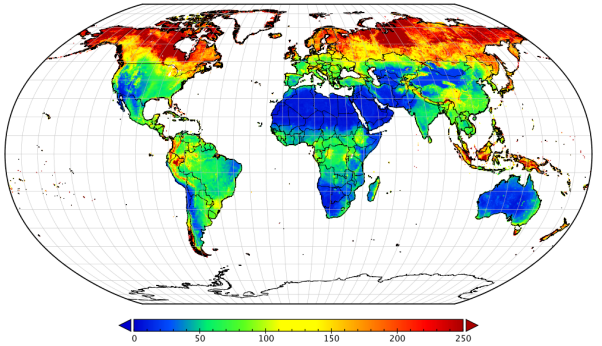
HWSD (1m)



Wise30Sec (1m)



GlobSoil (1m)

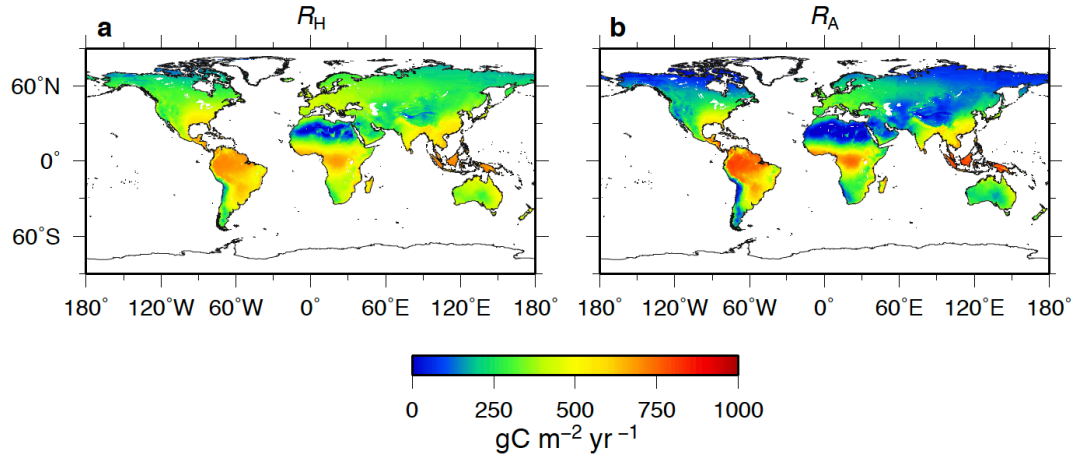


Biogeosciences, 12, 4121–4132, 2015
www.biogeosciences.net/12/4121/2015/
doi:10.5194/bg-12-4121-2015

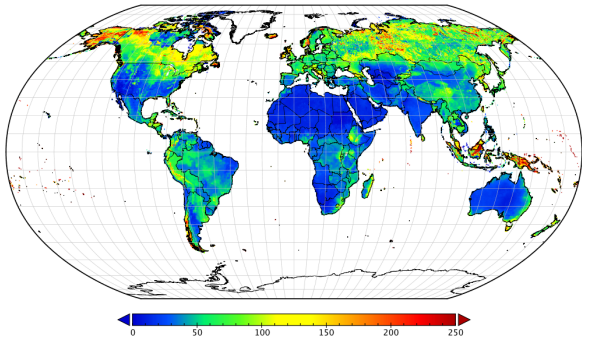
Biogeosciences Open Access

Global spatiotemporal distribution of soil respiration modeled using a global database

S. Hashimoto[1], N. Carvalhais[2,3], A. Ito[4,5], M. Migliavacca[2], K. Nishina[6], and M. Reichstein[2]



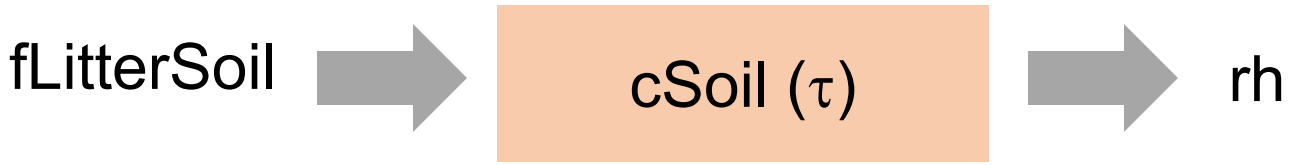
GSOC (30cm)



LUMIP paper plan: SOC and LUC

Future plans

- More models and experiments will be included
- Additional variables
  - pools: litter, slow/medium/fast components, soil1m, etc.
  - flows: fLitterSoil, rh, etc. => turnover time
- Manuscript preparation (by middle November?)



- I would sent a query about soil parameterization in each model

- Are you interested in? We are pleased to share a draft outline.
  => itoh@nies.go.jp

LUMIP paper plan: SOC and LUC

PERSPECTIVE

doi:10.1038/nature17174

Climate-smart soils

Keith Paustian[1,2], Johannes Lehmann[3], Stephen Ogle[2,4], David Reay[5], G. Philip Robertson[6] & Pete Smith[7]

Science and technology

Basic research on soil–plant processes

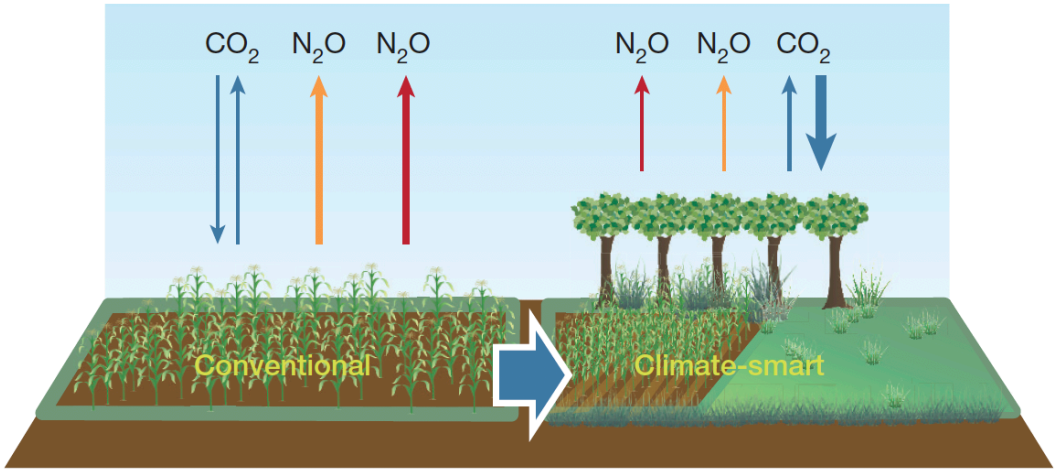
Research measurement networks

Soil monitoring networks

Advanced greenhouse gas networks

Remote sensing

Spatial databases and model integration



Practices

Reduced tillage

Biochar

Land restoration

Improved crop rotations

Organic amendments

Nutrient management

Cover crops

Agroforestry

Implementation

National and international greenhouse gas mitigation programme

Greenhouse gas offset and ecosystem service markets

Agricultural product supply chain management

Decision-support systems

Land-user engagement

LUMIP paper plan: SOC and LUC

SOIL, 2, 111–128, 2016
www.soil-journal.net/2/111/2016/
doi:10.5194/soil-2-111-2016

SOIL Open Access EGU

The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals

Saskia D. Keesstra[1], Johan Bouma[15,a], Jakob Wallinga[2], Pablo Tittonell[3], Pete Smith[4], Artemi Cerdà[5], Luca Montanarella[6], John N. Quinton[7], Yakov Pachepsky[8], Wim H. van der Putten[9,10], Richard D. Bardgett[11], Simon Moolenaar[12], Gerben Mol[13], Boris Jansen[14], and Louise O. Fresco[15]

Table 1. The UN "Sustainable Development Goals" for the period 2015–2030 (http://sustainabledevelopment.un.org/focussdgs.html), relatec to ecosystem services and soil functions, as discussed.

		Ecosystem services												
		Provision of food, wood and fibre	Provision of raw materials	Provision of support for human infrastructures and animals	Flood mitigation	Filtering of nutrients and contaminants	Carbon storage and greenhouse gas regulation	Detoxification and the recycling of wastes	Regulation of pests and disease populations	Recreation	Aesthetics	Heritage values	Cultural identity	Relates to soil
	SDG topic	1	2	3	4	5	6	7	8	9	10	11	12	function (Table 2)
1	End poverty in all its forms everywhere	X	X	X	X									1, 5
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	X		X										1, 2, 4
3	Ensure healthy lives and promote well-being for all at all ages	X							X	X	X	X	X	1, 2, 3, 4, 5, 7
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all												X	7
5	Achieve gender equality and empower all women and girls													
6	Ensure availability and sustainable management of water and sanitation for all				X	X		X		X				2
7	Ensure access to affordable, reliable, sustainable and modern energy for all	X	X											1, 5, 6
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	X	X	X										1, 2, 5, 6
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation		X	X										2, 4, 5
10	Reduce inequality within and among countries													
11	Make cities and human settlements inclusive, safe, resilient and sustainable		X	X										2, 4, 5,
12	Ensure sustainable consumption and production patterns	X	X			X	X	X						1, 2
13	Take urgent action to combat climate change and its impacts				X		X							2, 6
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development													
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	X	X	X	X	X	X	X	X	X		X	X	1, 2, 3, 4, 5, 6
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels			X						X		X	X	4, 7
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development													

LUMIP paper plan: SOC and LUC

Biogeosciences, 11, 2341–2356, 2014
www.biogeosciences.net/11/2341/2014/
doi:10.5194/bg-11-2341-2014

Biogeosciences Open Access

Changes in soil organic carbon storage predicted by Earth system models during the 21st century

K. E. O. Todd-Brown[1], J. T. Randerson[1], F. Hopkins[1], V. Arora[2], T. Hajima[3], C. Jones[4], E. Shevliakova[5], J. Tjiputra[6], E. Volodin[7], T. Wu[8], Q. Zhang[9], and S. D. Allison[1,10]