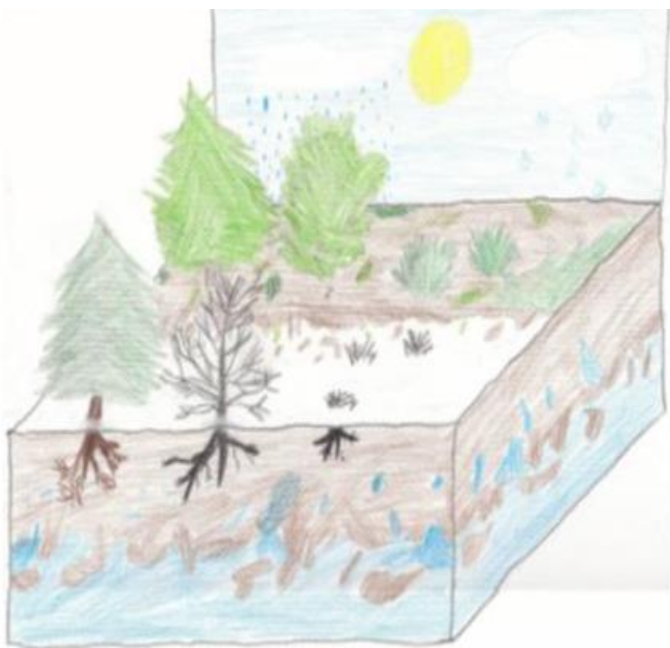
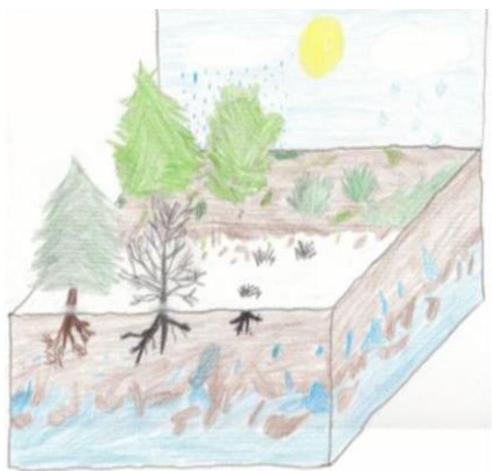
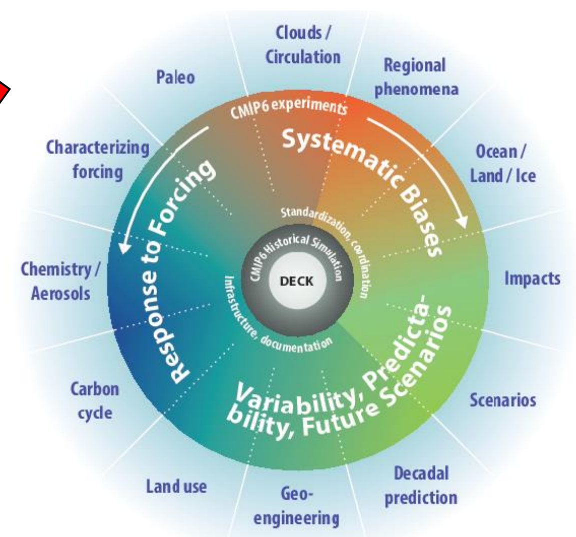
UiO : Department of Geosciences
University of Oslo

How can Emerald contribute to IPCC and CMIP (and vice versa)?



Society/Policymakers





Emerald

CMIP

EMERALD:

Scientific objectives: To improve representation of high latitude ecosystems and their climate interactions in the Norwegian Earth System model (NorESM) by integrating data and knowledge from empirical ecosystem research in model parameterization, development and testing.

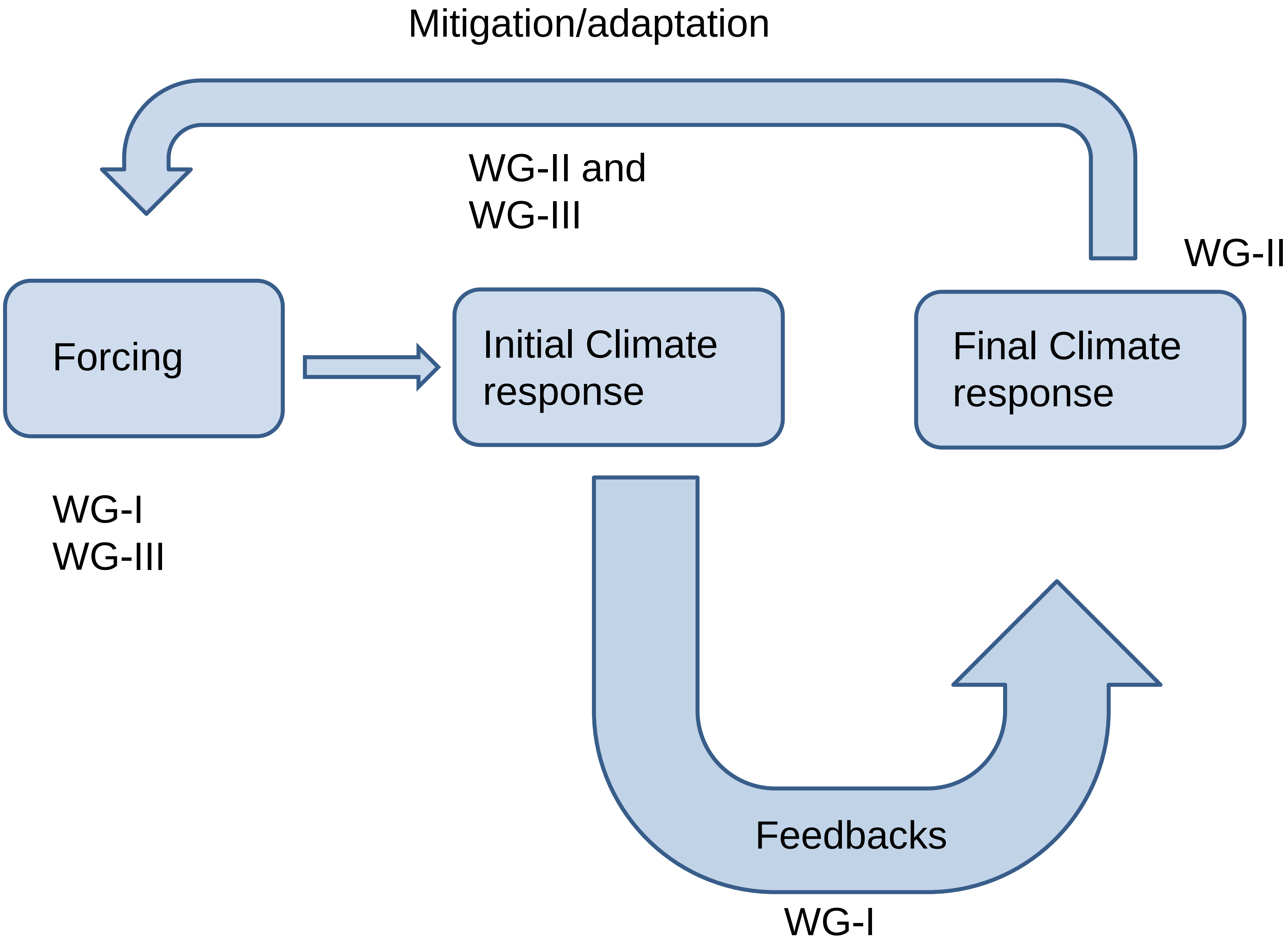
EMERALD objectives

WP1: Land surface model evaluation and improvement, Leads: Skarpaas, Lee, Tang
Main objective: *To target processes and parameters in CLM5BGC and CLM5FATES that need improvement for representing boreal, alpine and Arctic terrestrial ecosystems, and improve their representation by the help of observations and more detailed mechanistic models.*

WP2: Improved process understanding from observations and experiments
Leads: Vandvik, Bjerke, Pirk
Main objective: *Assemble existing and new measurements to improve process understanding and quantification of climate change impacts and feedbacks from terrestrial ecosystems.*

WP3: Implementation in NorESM and quantification of feedbacks.
Leads: Berntsen, Bright, Westermann
Main objective: *To quantify the net impacts of model improvements (WP1) when incorporated in NorESM.*

WP4: Dissemination and communication. Leads: Hisdal, Bryn and Parmentier.
Main objective: *to inform the general public about the little-known interactions between ecosystems and the climate system, and improve the basis for climate change adaptation and further studies on the impacts of climate change on nature and society.*


Mitigation/adaptation
WG-II and
WG-III
WG-II
Forcing
Initial Climate
response
Final Climate
response
WG-I
WG-III
Feedbacks
WG-I

AR6 Schedule

IPCC WG-I Timeline

2019

APRIL
7 April
Submission of the First Order Draft (FOD) to TSU
8-21 April
TSU compiles FOD
29 April - 23 June
Expert Review of FOD

JULY
1 July
TSU sends compiled Review Comments to CLAs

AUG
26-31 August
Third Lead Author Meeting (LAM3)

OCT
7 October
Comment responses & RE First interim report due to TSU

DEC
31 December
Literature submission cut off

2020

JAN
12 January
Submission of the Second Order Draft (SOD) to TSU
13-26 January
TSU compile SOD

MAR
2 March - 26 April
Expert and Government Review of the SOD and of the FOD of the Summary for Policy Makers (SPM)

MAY
4 May
TSU send compiled Review Comments to CLAs

JUNE
1-6 June
Fourth Lead Author Meeting (LAM4)
29 June
RE second Interim report due to TSU

JULY
27 July
SOD Review Comments response due to TSU

SEPT
30 September
Literature acceptance cut off

OCT
18 October
Submission of the Final Draft (FGD) to TSU

DEC
19 October - 1 November
TSU compiles FGD
7 December - 31 January
Final Government Distribution

2021

FEB
8 February
TSU send compiled Review Comments to SPM Drafting Team

APR
12-16 April
IPCC 54 - Approval Session

SECTION 1: Risks, adaptation and sustainability for systems impacted by climate change

Chapter 2: Terrestrial and freshwater ecosystems and their services [60 pages]

- Trends in critical ecosystems including detection and attribution of observed impacts and responses
- Projected hazards and exposure (link to WGI), including extreme events and interactions of multiple climatic, non-climatic and anthropogenic stressors at relevant temporal and spatial scales
- Projected impacts: species, ecosystem structure and biodiversity, emergence of novel communities, process rates, functions, and the implication for their services, at relevant temporal and spatial scales
- Vulnerability and resilience, enablers and limits to natural and planned adaptation, and maladaptation
- Assessing risks, opportunities, costs, and trade-offs including consideration of scenarios and impacts of adaptation and mitigation responses

IPCC WG-II Timeline

Timeline IPCC WGII AR6

2019

Month	Date	Event
JAN	**21 – 25 Jan 2019**	First Lead Author Meeting (Durban, South Africa)
APR	**26 April 2019**	Internal Draft submitted to TSU
	29 April – 9 May 2019	TSU compile Internal Draft
MAY	**10 May – 21 June 2019**	Internal Draft Review
JUN	**28 June 2019**	TSU send compiled review comments to CLAs (date tbc)
JUL	**15 – 19 July 2019**	Second Lead Author Meeting (Kathmandu, Nepal)
OCT	**4 October 2019**	First Order Draft submitted to TSU
	7 – 18 October 2019	TSU compile First Order Draft
OCT	**18 October – 13 December 2019**	Expert Review of First Order Draft
DEC	**20 December 2019**	TSU send compiled review comments to CLAs (date tbc)

2020

Month	Date	Event
JAN	**27 January – 1 February 2020**	Third Lead Author Meeting (Faro, Portugal)
JUN	**1 July 2020**	cut-off date for submitted papers
JUL	**10 July 2020**	Second Order Draft submitted to TSU
	13 July – 6 August 2020	TSU compile Second Order Draft
AUG	**7 August – 2 October 2020**	Expert and Government Review of Second Order Draft
OCT	**9 October 2020**	TSU send compiled review comments to CLAs (date tbc)
NOV	**2 – 7 November 2020**	Fourth Lead Author Meeting (location tbc)

2021

Month	Date	Event
MAY	**1 May 2021**	cut-off date for accepted papers
	14 May 2021	Final Draft submitted to TSU
	17 – 27 May 2021	TSU compile Final Draft
JUN	**28 May – 23 July**	Final Government Distribution of the Final Draft and Government Review of the Summary for Policymakers

Chapter 7: Agriculture, Forestry, and Other Land Uses (AFOLU)

• Mitigation measures – supply and demand - effectiveness, costs, economics
• Mitigation potentials – supply and demand - global and regional
• Constraints and opportunities across different contexts and regions
• Provision of food, feed, fibre, wood, biomass for energy, and other ecosystem services and resources from land, including interactions in the context of mitigation strategies and pathways
• Mitigation approaches within food production and food security strategies
• Anthropogenic emissions and removals in each of agriculture, forestry, other land uses, and non-managed terrestrial ecosystems, and their implications for mitigation pathways, considering a range of sources of information

IPCC AR6 WGIII (Mitigation) Report Schedule

IPCC WG-III Timeline

2019

APR — **1-5 Apr**
First Lead Author Meeting (LAM1), Edinburgh, UK

SEP — **30 Sep-4 Oct**
Second Lead Author Meeting (LAM2), Location TBC

2020

JAN — **13 Jan-8 Mar**
Expert Review of First Order Draft

APR — **13-17 Apr**
Third Lead Author Meeting (LAM3), Location TBC

JUN — **15 Jun**
Literature deadline: cut-off date for submitted papers
Literature for consideration by report authors must be submitted to publishers by this date

JUL — **13 Jul-13 Sep**
Expert & Government Review of the SOD & the FOD of the Summary for Policymakers (SPM)

OCT — **25-31 Oct**
Fourth Lead Author Meeting (LAM4), Location TBC

2021

JAN — **19 Jan**
Literature deadline: cut-off date for accepted papers
Literature for consideration by report authors must be accepted for publication by this date

FEB — **15 Feb-11 Apr**
Final Government Distribution (FGD)

JUL — **9-10 Jul**
SPM Meeting, Location TBC

12-16 Jul
Approval Plenary, Location TBC

Coupled Model Intercomparison Project Phase 6 (CMIP6)

With the Grand Science Challenges of the World Climate Research Programme (WCRP) as its scientific backdrop, CMIP6 will address three broad questions:

– How does the Earth system respond to forcing?

– What are the origins and consequences of systematic model biases?

– How can we assess future climate changes given internal climate variability, predictability, and uncertainties in scenarios?

Geosci. Model Dev., 9, 1937–1958, 2016
www.geosci-model-dev.net/9/1937/2016/
doi:10.5194/gmd-9-1937-2016

Geoscientific Model Development
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EGU

Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization

Veronika Eyring[1], Sandrine Bony[2], Gerald A. Meehl[3], Catherine A. Senior[4], Bjorn Stevens[5], Ronald J. Stouffer[6], and Karl E. Taylor[7]

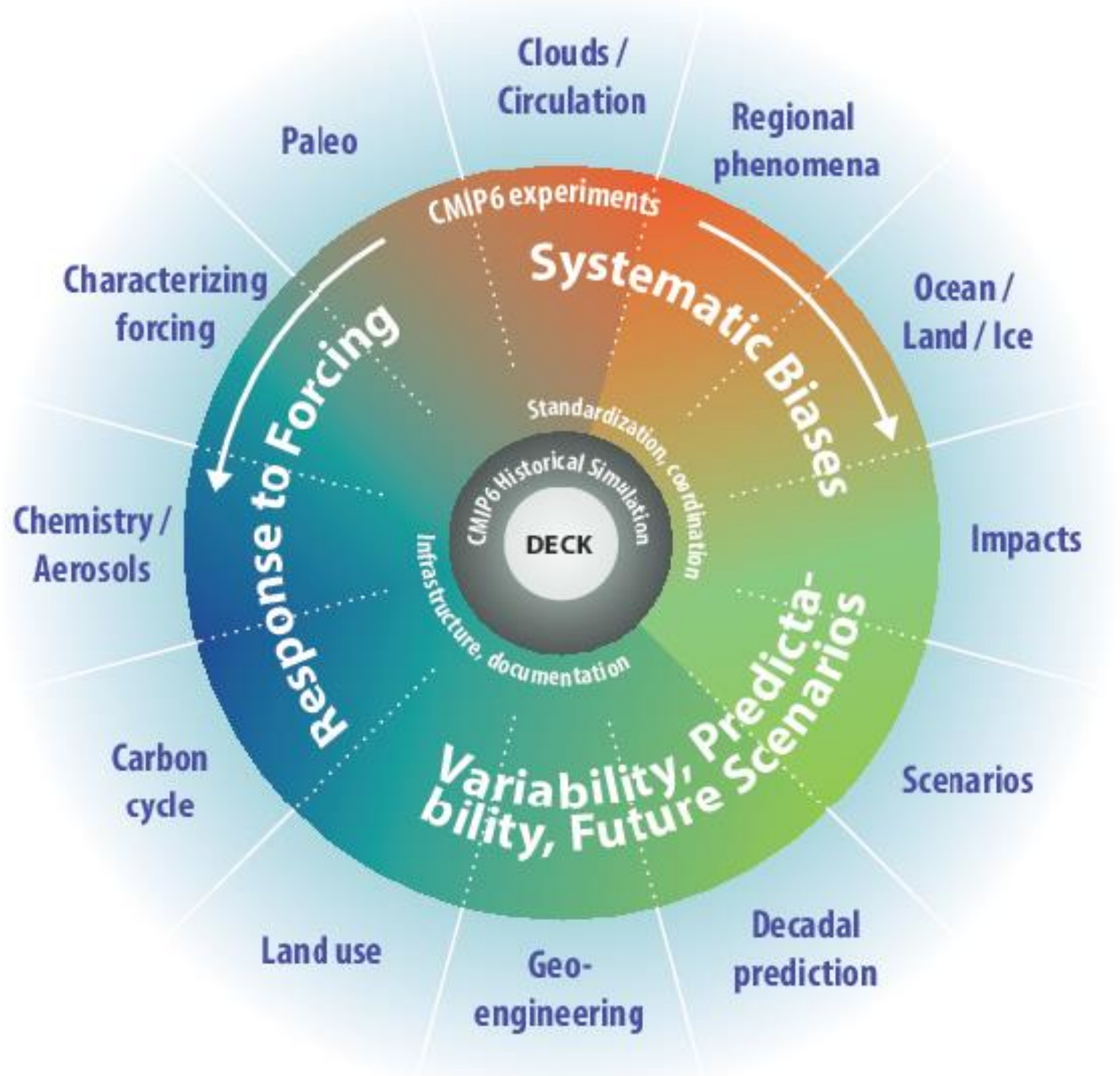
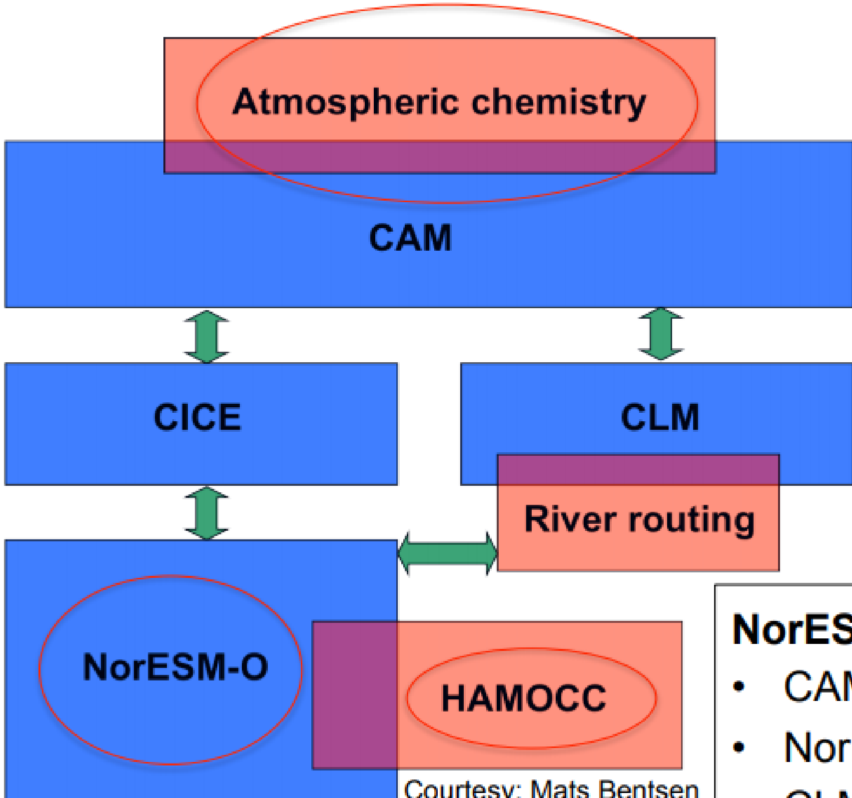


Figure 2. Schematic of the CMIP/CMIP6 experiment design. The

DECK (Diagnostic, Evaluation and Characterization of Klima)

Experiment short name	CMIP6 label	Experiment description	Forcing methods	Start year	End year	Minimum no. years per simulation	Major purpose
DECK experiments							
AMIP	*amip*	Observed SSTs and SICs prescribed	All; CO_2 concentration prescribed	1979	2014	36	Evaluation, variability
Pre-industrial control	*piControl* or *esm-piControl*	Coupled atmosphere–ocean pre-industrial control	CO_2 concentration prescribed or calculated	n/a	n/a	500	Evaluation, unforced variability
Abrupt quadrupling of CO_2 concentration	*abrupt-4×CO2*	CO_2 abruptly quadrupled and then held constant	CO_2 concentration prescribed	n/a	n/a	150	Climate sensitivity, feedback, fast responses
$1\,\%\,\mathrm{yr}^{-1}$ CO_2 concentration increase	*1pctCO2*	CO_2 prescribed to increase at $1\,\%\,\mathrm{yr}^{-1}$	CO_2 concentration prescribed	n/a	n/a	150	Climate sensitivity, feedback, idealized benchmark
CMIP6 historical simulation							
Past ~ 1.5 centuries	*historical* or *esm-hist*	Simulation of the recent past	All; CO_2 concentration prescribed or calculated	1850	2014	165	Evaluation

Norwegian Earth System Model



Components in blue communicate through a coupling component.

Components in red are subroutines of blue components.

Variant of CESM with key modifications

1. Aerosol life cycle and cloud interaction from Oslo (CAM-OSLO)
2. Isopycnic coordinate ocean model (NorESM-O) based on MICOM
3. Hamburg Ocean Carbon Cycle biogeochemistry model (HAMOCC) adapted to isopycnic coordinates
4. Ensemble Kalman-filter assimilation adapted to isopycnic coordinates

NorESM1-M (Bentsen et al. 2012, Iversen et al. 2012)

- CAM4-Oslo (1.9x2.5, L26)
- NorESM-O (1deg gx1-grid, L53)
- CLM4, CICE4, CPL7 as in CCSM4

CMIP5

NorESM1-ME (Tjiputra et al. 2012)

- based on CESM1 and includes HAMOCC
- otherwise same as NorESM1-M

https://wiki.met.no/_media/noresm/BethkeEtAl_CCliCS2016_v2.pdf

Climate Sensitivity in CESM2

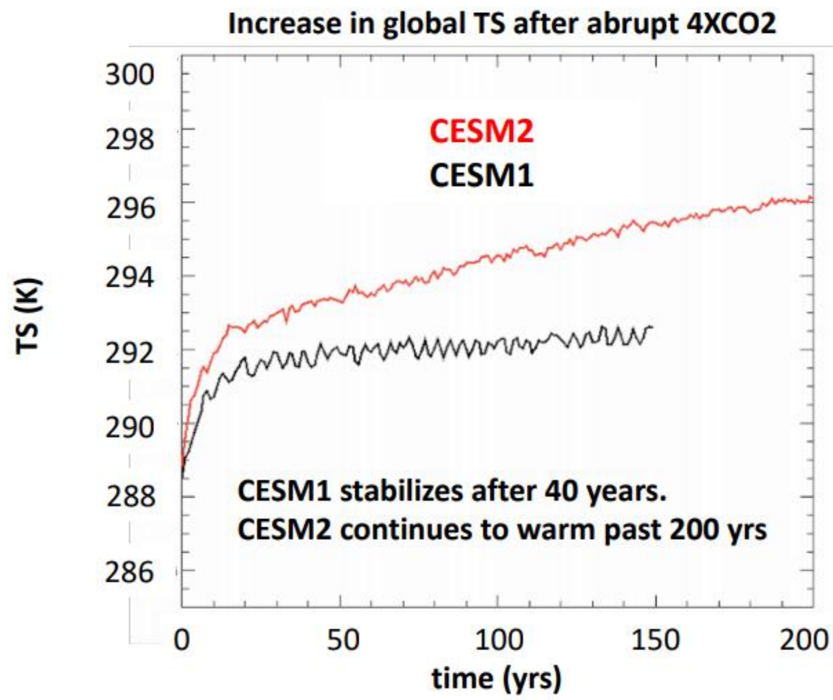
- **Equilibrium Climate Sensitivity (ECS) is larger in CESM2 than in prev versions of the model.**

Equilibrium Climate Sensitivity

CCSM3 (CAM3)	2.9 K
CCSM4 (CAM4)	3.2 K
CESM1 (CAM5)	4.1 K
CESM2 (CAM6)	5.3 K

***IPCC (AR5):* ECS is likely between 1.5°C and 4.5°C**

- **Why is ECS larger ?**

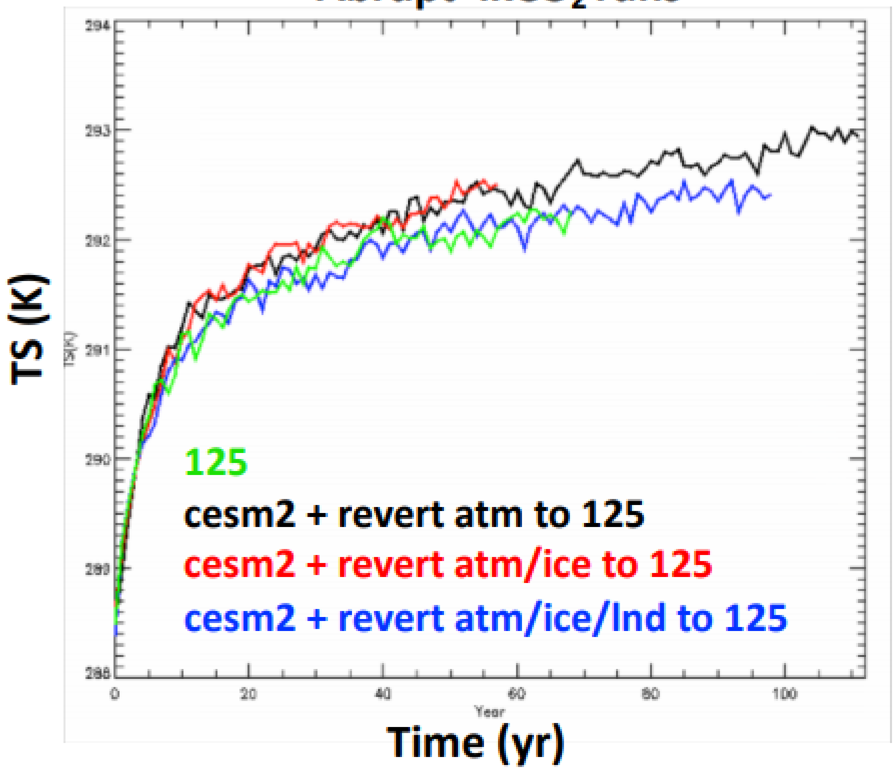


http://www.cesm.ucar.edu/events/wg-meetings/2019/presentations/AMWGChemWAWG/hannay.pdf

Between 125 ⇔ CESM2

- **Change in sea-ice albedos**
- **Change in land parameters (and many other things)**
- **Change in ocean coupling frequency and Robert filter**

Abrupt $4xCO_2$ runs

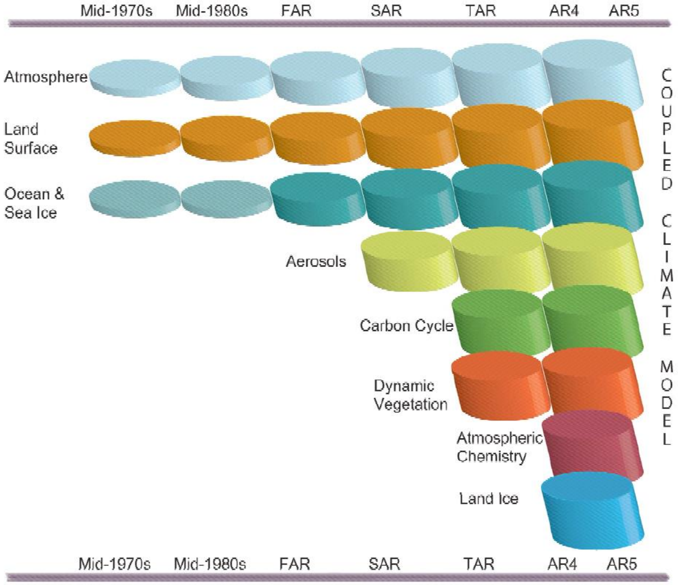


Reverting atmosphere and land parameters to 125 reverts to CESM1 behavior

http://www.cesm.ucar.edu/events/wg-meetings/2019/presentations/AMWGChemWAWG/hannay.pdf

How to get improvements into CLM/NorESM ➔ CMIP/IPCC?

1. Coding and validation
   a. Stand alone column, current climate
   b. Stand alone column, future forcing (climate,++)
   ➔ Proof of concept
2. Global simulation, fixed SST, Sea Ice
   ➔ Assess feedbacks
3. Optimization of code
4. Coupled simulation
   a. Control run(s)/tuning
5. Production runs



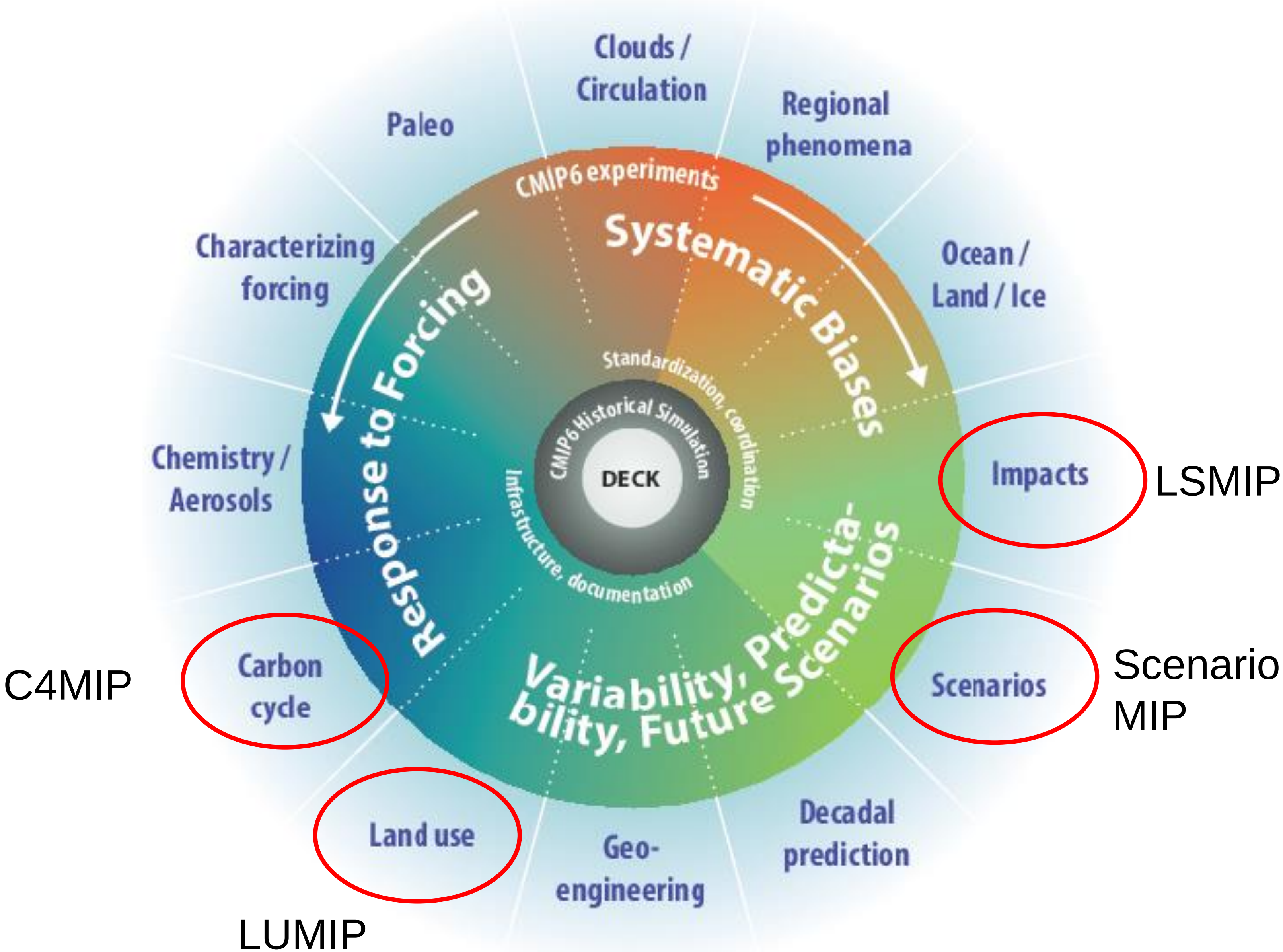


Figure 2. Schematic of the CMIP/CMIP6 experiment design. The

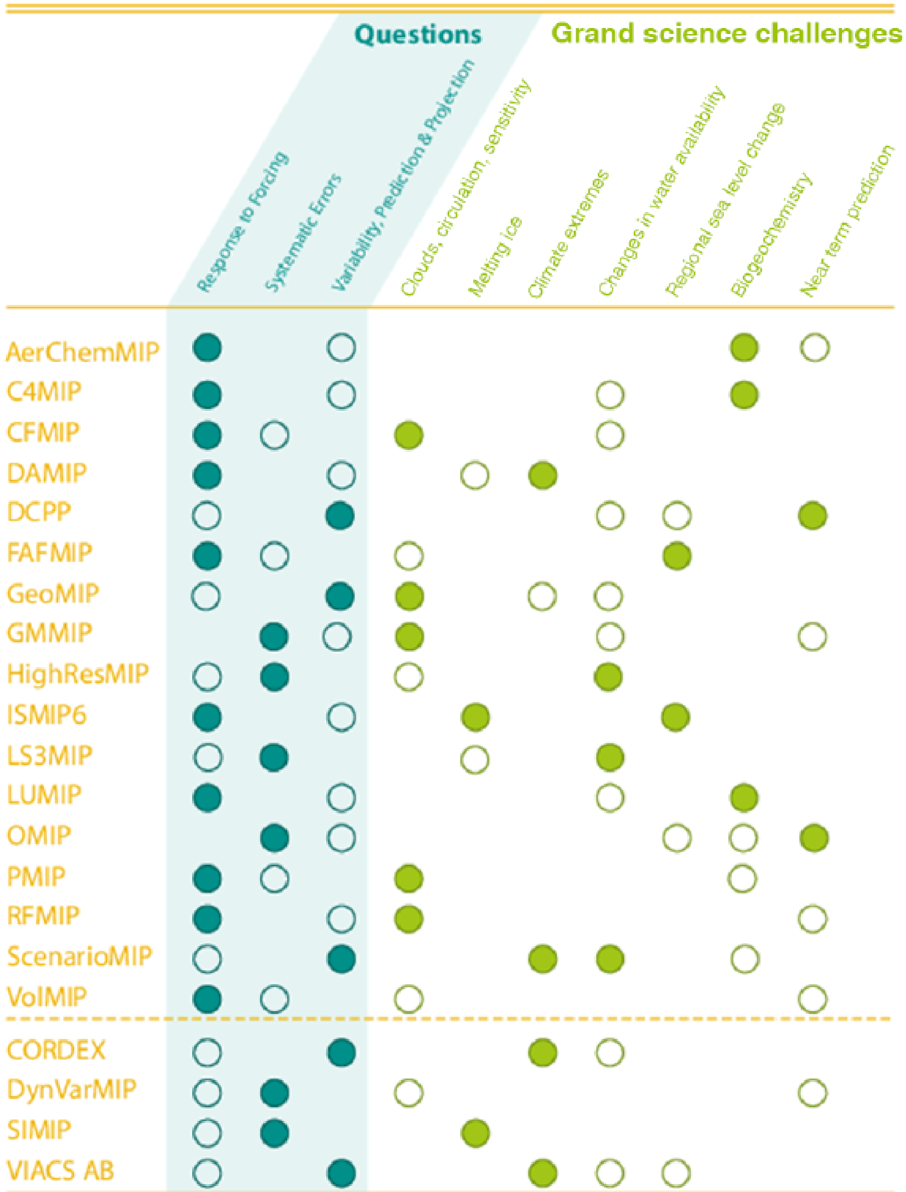


Figure 3. Contributions of CMIP6-Endorsed MIPs to the three CMIP6 science questions and the WCRP Grand Science Challenges. A filled circle indicates highest priority and an open circle, second highest priority. Some of the MIPs additionally contribute

The LS3MIP experiments objectives:

– Evaluate land processes including surface fluxes, snow cover and soil moisture representation in CMIP DECK experiments and historical simulations, to identify the main systematic biases and their dependencies

– Estimate long-term terrestrial energy/water/carbon cycles, under observation-constrained historical (land reanalysis) and projected future (impact assessment) climatic conditions considering land use/land cover changes;

– Assess snow and soil moisture feedbacks in the regional response to climate forcings, focusing on controls of climate extremes, water availability and high-latitude climate in historical and future scenario runs

– Assess the contribution of land surface processes to systematic ESM biases and the current and future predictability of regional temperature/ precipitation patterns.

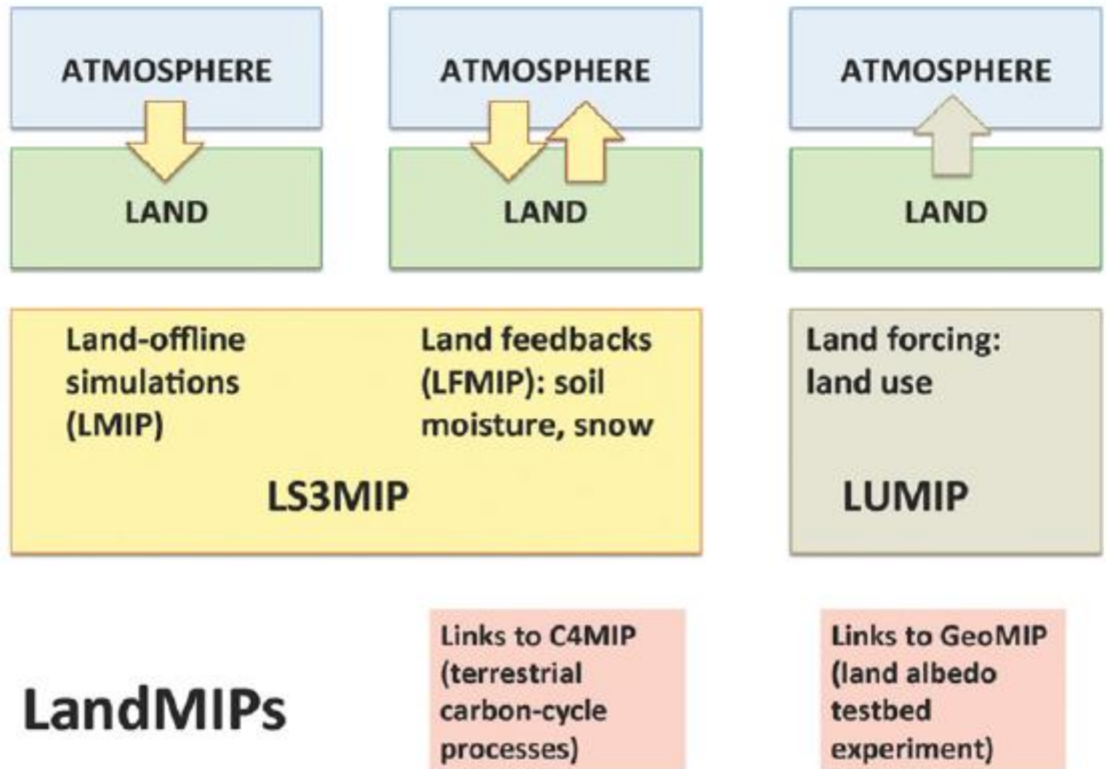


Figure 1. Structure of the "LandMIPs". LS3MIP includes (1) the offline representation of land processes (LMIP) and (2) the representation of land–atmosphere feedbacks related to snow and soil moisture (LFMIP). Forcing associated with land use is assessed in LUMIP. Substantial links also exist to C4MIP (terrestrial carbon cycle). Furthermore, a land albedo test bed experiment is planned within GeoMIP. From Seneviratne et al. (2014).

Land Use MIP (LUMIP)

The main science questions that will be addressed by LUMIP:

– What are the global and regional effects of land-use and land-cover change on climate and biogeochemical cycling (past–future)?

– What are the impacts of land management on surface fluxes of carbon, water, and energy?

– Are there regional land-use or land-management strategies with the promise to help mitigate climate change?

Geosci. Model Dev., 9, 2973–2998, 2016
www.geosci-model-dev.net/9/2973/2016/
doi:10.5194/gmd-9-2973-2016

Geoscientific Model Development
Open Access
EGU

The Land Use Model Intercomparison Project (LUMIP) contribution to CMIP6: rationale and experimental design

David M. Lawrence[1], George C. Hurtt[2], Almut Arneth[3], Victor Brovkin[4], Kate V. Calvin[5], Andrew D. Jones[6], Chris D. Jones[7], Peter J. Lawrence[1], Nathalie de Noblet-Ducoudré[8], Julia Pongratz[4], Sonia I. Seneviratne[9], and Elena Shevliakova[10]

C4MIP

The Coupled Climate–Carbon Cycle Model Intercomparison Project

C4MIP experiments:

– Idealized experiments, which will be used to separate and quantify the sensitivity of land and ocean carbon cycle to changes in climate and atmospheric CO_2 concentration

– Historical experiments, which will be used to evaluate model performance and investigate the potential for using contemporary observations as a constraint on future projections

– Future scenario experiments, which will be used to quantify future changes in carbon storage and hence

Geosci. Model Dev., 9, 2853–2880, 2016
www.geosci-model-dev.net/9/2853/2016/
doi:10.5194/gmd-9-2853-2016

Geoscientific Model Development
Open Access

C4MIP – The Coupled Climate–Carbon Cycle Model Intercomparison Project: experimental protocol for CMIP6

Chris D. Jones[1], Vivek Arora[2], Pierre Friedlingstein[3], Laurent Bopp[4], Victor Brovkin[5], John Dunne[6], Heather Graven[7], Forrest Hoffman[8], Tatiana Ilyina[5], Jasmin G. John[6], Martin Jung[9], Michio Kawamiya[10], Charlie Koven[11], Julia Pongratz[5], Thomas Raddatz[5], James T. Randerson[12], and Sönke Zaehle[9]

C4MIP

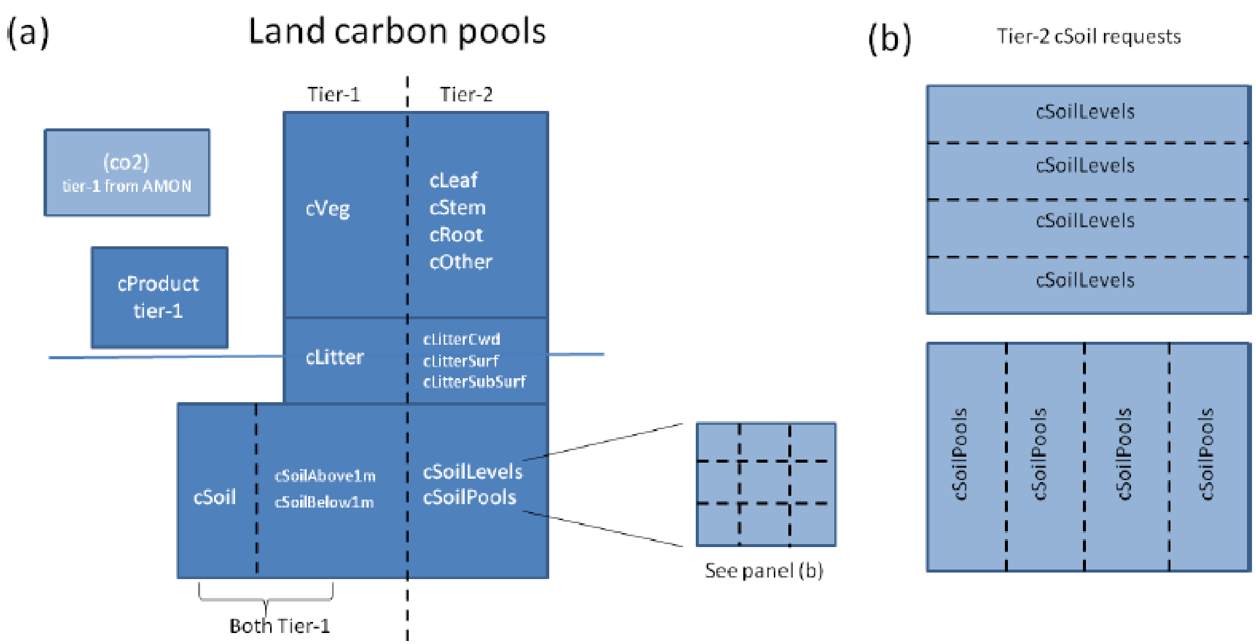


Figure 5. (a) Requested tier-1 and tier-2 variables representing land carbon pools. Although not a land carbon quantity, atmospheric CO_2 is shown here for completeness. **(b)** Detailed view of the tier-2 breakdown for soil carbon by vertical level (cSoilLevels) and by soil carbon pool (cSoilPools).

ScenarioMIP

ScenarioMIP has three primary objectives:

a. Facilitate integrated research leading to a better understanding not only of the physical climate system consequences of these scenarios, but also of the climate impact on societies. The results of the ScenarioMIP experiments will provide new climate information for future scenarios that will facilitate integrated research across multiple communities including the (1) climate science, (2) integrated assessment modeling, and (3) impacts, adaptation, and vulnerability communities. This research will be key in informing mitigation and adaptation policy considerations, including processes that are part of the UN Framework Convention on Climate Change (UNFCCC) such as the 2015 Paris Climate Agreement.

b. Provide a basis for addressing targeted science questions in ScenarioMIP and other CMIP6 projects, regarding the climate effects of particular aspects of forcing relevant to scenario-based research. This includes the effects of a substantial overshoot in radiative forcing and the effect of different assumptions on land use and near-term climate forcers (NTCFs; namely tropospheric aerosols, tropospheric O3 precursors, and CH4/ on climate change and its impacts. Therefore, a set of variants of the scenarios proposed here are being proposed in other CMIP6-Endorsed MIPs

c. Provide a basis for research efforts that target improved methods to quantify projection uncertainties based on multi-model ensembles, taking into account model performance, model dependence and observational uncertainty. This extends the knowledge basis derived from the Diagnostic, Evaluation and Characterization of Klima (DECK) experiments and the CMIP6 historical simulations (Eyring et al., 2016) and allows for the quantification of uncertainties on different timescales. ScenarioMIP will provide some of the results needed in the next IPCC assessment to characterize the uncertainty in future climate and impacts.

Geosci. Model Dev., 9, 3461–3482, 2016
www.geosci-model-dev.net/9/3461/2016/
doi:10.5194/gmd-9-3461-2016

Geoscientific Model Development
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The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6

Brian C. O'Neill[1], Claudia Tebaldi[1], Detlef P. van Vuuren[2,3], Veronika Eyring[4], Pierre Friedlingstein[5], George Hurtt[6], Reto Knutti[7], Elmar Kriegler[8], Jean-Francois Lamarque[1], Jason Lowe[9], Gerald A. Meehl[1], Richard Moss[10], Keywan Riahi[11,12], and Benjamin M. Sanderson[1]

ScenarioMIP

ScenarioMIP has three primary objectives:

a. Facilitate integrated research leading to a better understanding not only of the physical climate system, but also of the climate impact on societies. The results will facilitate integrated research across (1) climate science, (2) integrated assessment modeling, and (3) impacts, adaptation, and vulnerability communities. This research will be informing mitigation and adaptation policy, including the UNFCCC (e.g. 2015 Paris Agreement).

b. Provide a basis for addressing questions such as effects of a substantial overshoot in radiative forcing and the effect of different assumptions on land use and near-term climate forcers (SLCFs; namely aerosols, ozone , and CH4)

c. Quantify projection uncertainties based on multi-model ensembles, taking into account model performance, model dependence and observational uncertainty. This extends the knowledge basis derived from the DECK experiments and the historical simulations. ScenarioMIP will provide some of the results needed in the next IPCC assessment to characterize the uncertainty in future climate and impacts.

Geosci. Model Dev., 9, 3461–3482, 2016
www.geosci-model-dev.net/9/3461/2016/
doi:10.5194/gmd-9-3461-2016

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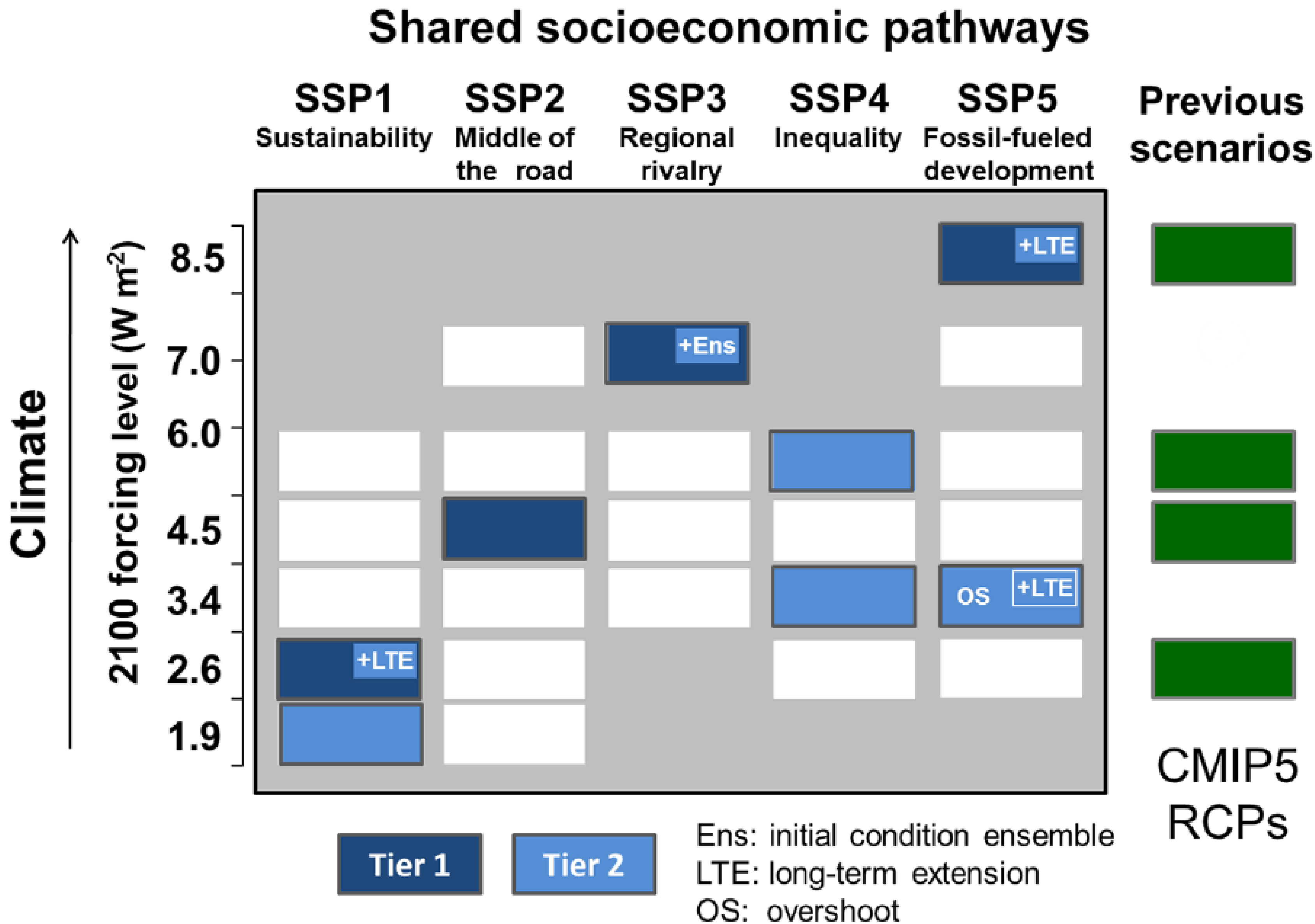
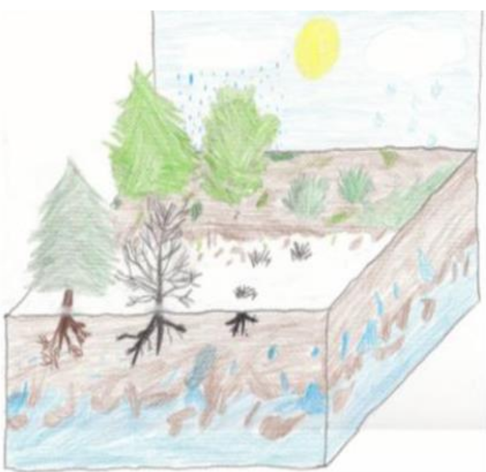
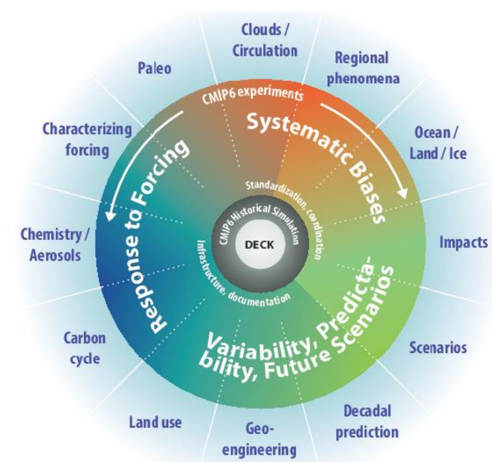

Shared socioeconomic pathways
SSP1
Sustainability
SSP2
Middle of the road
SSP3
Regional rivalry
SSP4
Inequality
SSP5
Fossil-fueled development
Previous scenarios
Climate
2100 forcing level (W m⁻²)
8.5
7.0
6.0
4.5
3.4
2.6
1.9
+LTE
+Ens
OS
CMIP5 RCPs
Tier 1
Tier 2
Ens: initial condition ensemble
LTE: long-term extension
OS: overshoot

Summary

- Register and Contribute as Expert Reviewers to IPCC
- Process studies are always useful and welcome. Be aware of cut-off dates
- CMIP6: Trains have left the stations (wrt. EMERALD contributions)
- CMIP7 (202?) through CLM-improvements within NorESM (or CESM). Need to be aware of process/requirements

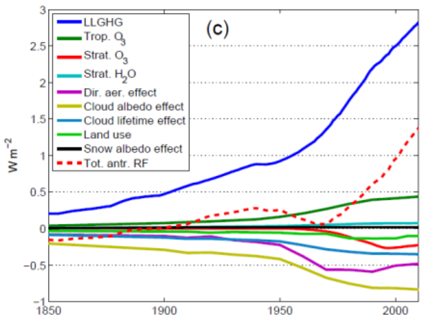


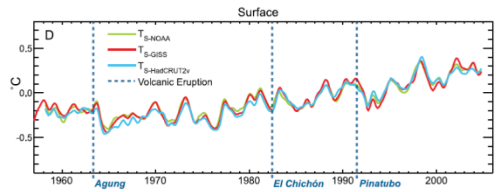
Emerald

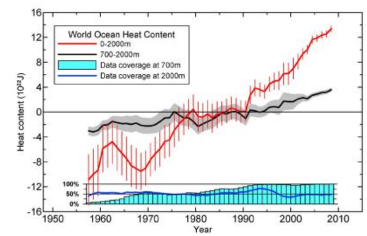


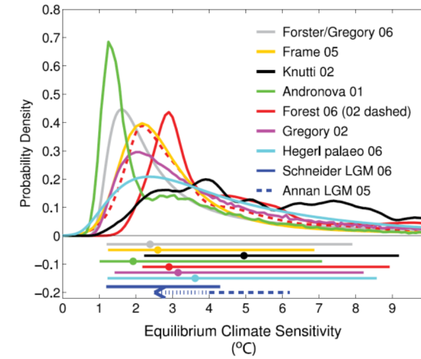
CMIP

Estimating climate sensitivity: Two approaches







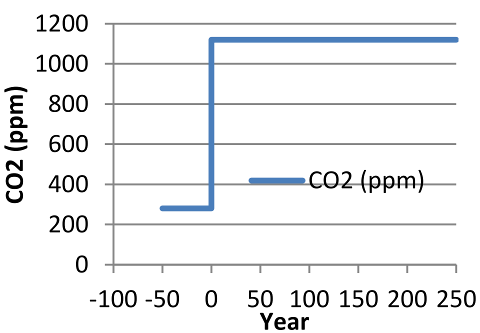


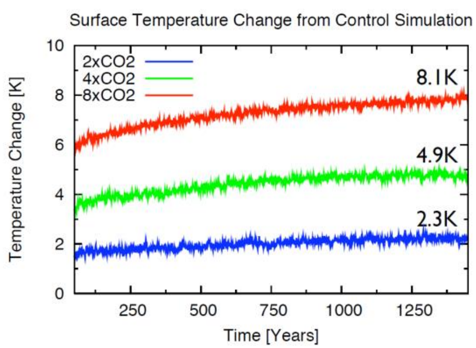
Historic forcing

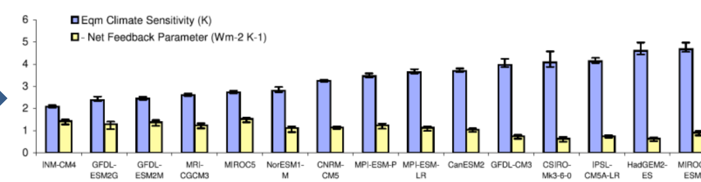
Climate system response

Observed response

Estimated climate sensitivity







Idealized Stepwise forcing in ESMs

Calculated response in ESMs.

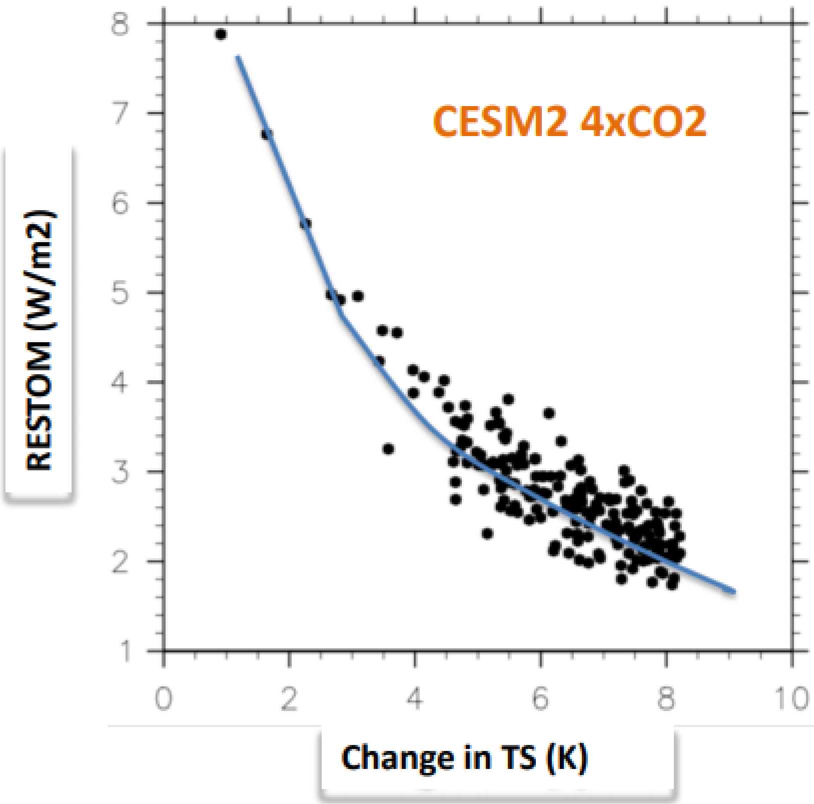
CCSM3, Jonko et al.

Range from CMIP5 (2.1-4.7K),

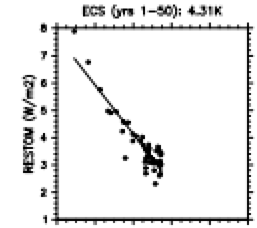
Andrews et al., GRL, 2012

Gregory method's caveat for coupled run

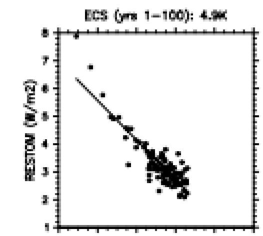
Gregory method: Use linear fit between RESTOM and ΔT



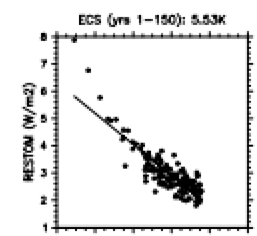
Yrs 1-50
ECS = 4.31 K



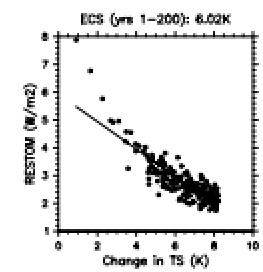
Yrs 1-100
ECS = 4.9 K



Yrs 1-150
ECS = 5.5 K



Yrs 1-200
ECS = 6.0 K



If non linear relationship,
ECS strongly depends on the chosen period
=> It is hard to give a number for ECS