

Proposal for a Land-Use Model Inter-comparison Project (LUMIP) for CMIP6

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with input from many from Earth System Modeling, Integrated Assessment
Modeling, and historical land use communities

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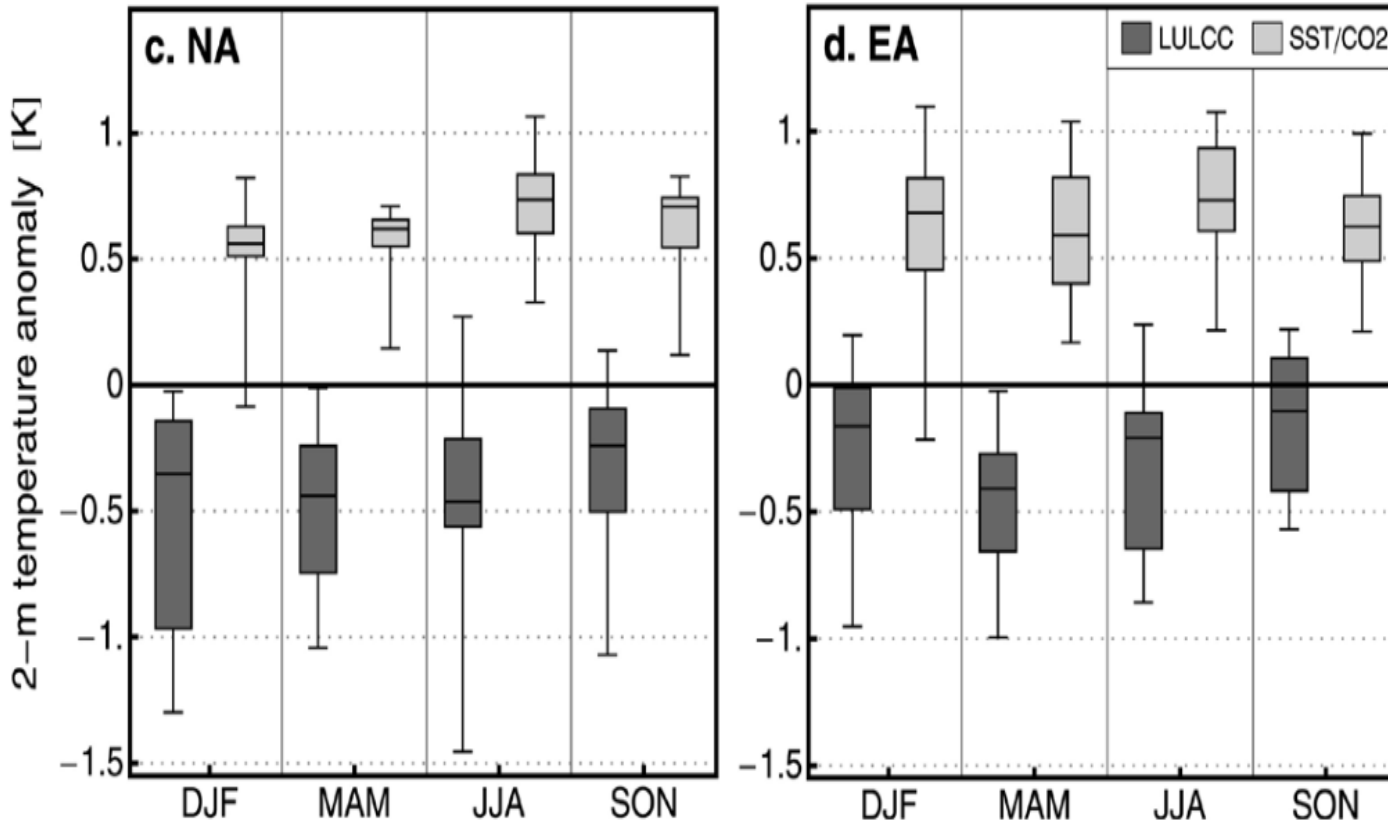
What has been learned (LUCID, CMIP5, etc)?

- Land-use effects on global climate are generally modest relative to FF, but still important, especially regionally
- Land-use climate effects are complex and challenging to diagnose; models often do not agree on amplitude or even sign of impact
- More detailed/systematic assessment of land models (and atmosphere models) response to land use is required in order to be able to understand climate response
- Climate extremes appear to be sensitive to land use
- Land-use transitions are needed for accurately tracking land cover change resulting from land-use change
- Models implemented standardized land-use data sets differently
- Potentially important impacts, management practices, biogeophysical effects, policy options, uncertainties, and feedbacks not adequately accounted for in prior experimental designs

Results from LUCID/CMIP5

North America

Eurasia



CO₂ + SST + SIC forcing leads to warming

LULCC leads to cooling

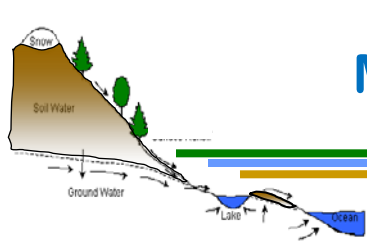
LUMIP Major Activities

- **Data standardization**
 - Repeat and mature land use harmonization process resulting in enhanced standardized land-use data set for CMIP6, passing the maximum amount of common information between relevant communities (Historical, IAMs, ESMs)
 - Provide additional required land management datasets
- **Model metrics and diagnostics**
 - A set of metrics will be developed to quantify model performance with respect to land use impacts on climate
 - A diagnostic protocol will also be developed to quantify related model sensitivities (expressed as RF?)
- **Model experiments**
 - Development of efficient model experiments designed to isolate and quantify land use and land management effects

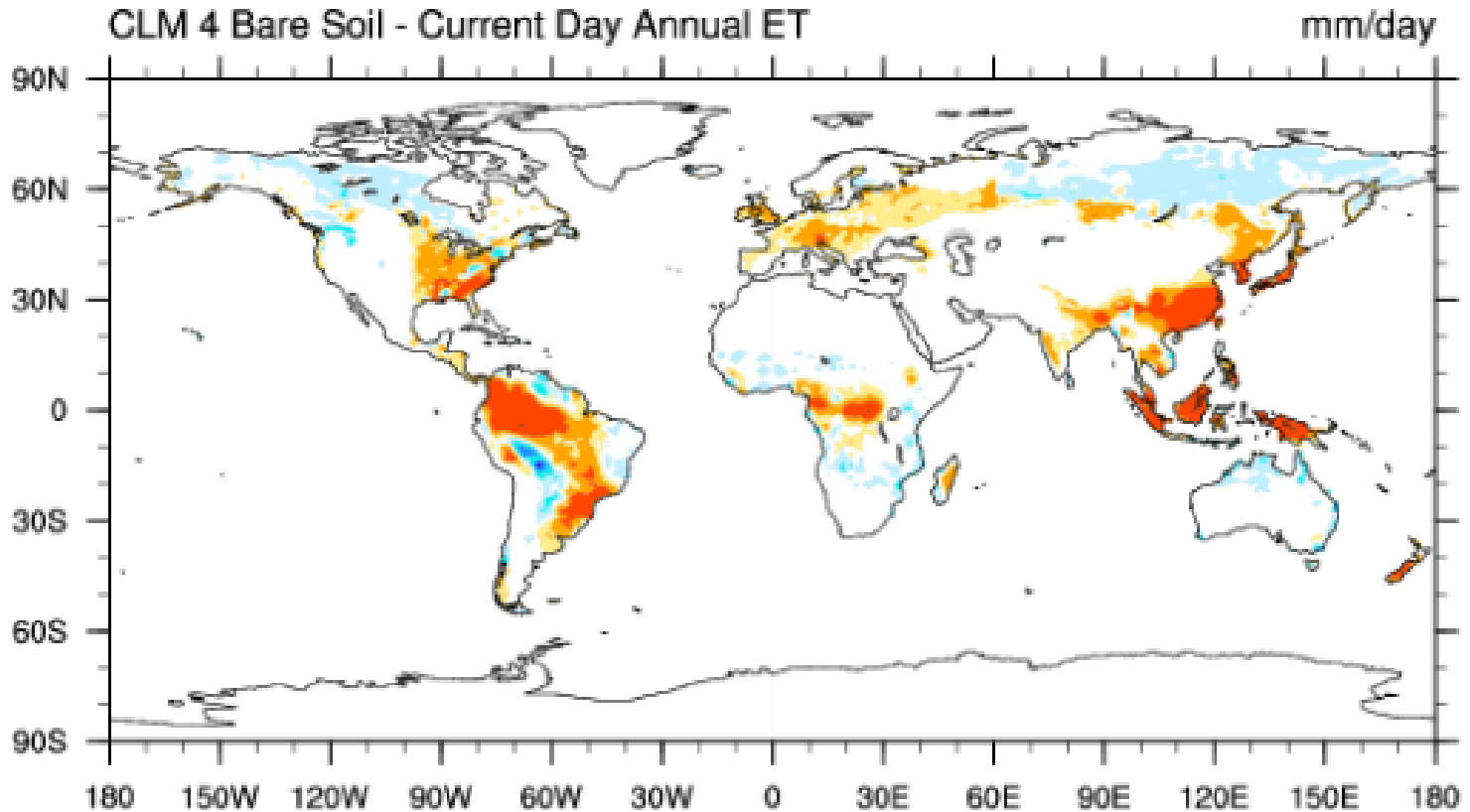
Developing experimental design (2 phases?)

- **Preliminary work (funding?):**
 - Investigate relative influence of land use practices / model capabilities
 - prognostic crop, irrigation, wood harvest, fertilization, ???
 - Development of standardized metrics
 - Establish requirements
 - # of ensembles (CESM Large Ensemble?)
 - Resolution, scales of land-use change that are detectable
 - Define and utilize idealized scenarios (e.g. complete Amazon deforestation) to enhance process understanding

Model development: Utilizing idealized experiments



Complete removal of vegetation



Bare soil has higher ET than forests (???)

Developing experimental design (2 phases?)

- **LUMIP experiments for CMIP6**
 - Coordinated (limited) set of coupled and offline experiments designed to isolate land use and land management impacts on climate (biogeophysics and biogeochemistry)
 - LUMIP experimental design should complement other MIPs

Participation and Relationship to Other MIPS

- Participation in LUMIP will be open
- LUMIP will be coordinated by a small interdisciplinary and engaged working group, report to CMIP6 panel, and linked to other CMIP satellite MIPS
- LUMIP will work with other related MIPS and activities including: LUCID, C4MIP, AGMIP, GSWP3, Trendy, LUC4C, GLP, iLeaps, etc.
- Major role of LUMIP will be coordination

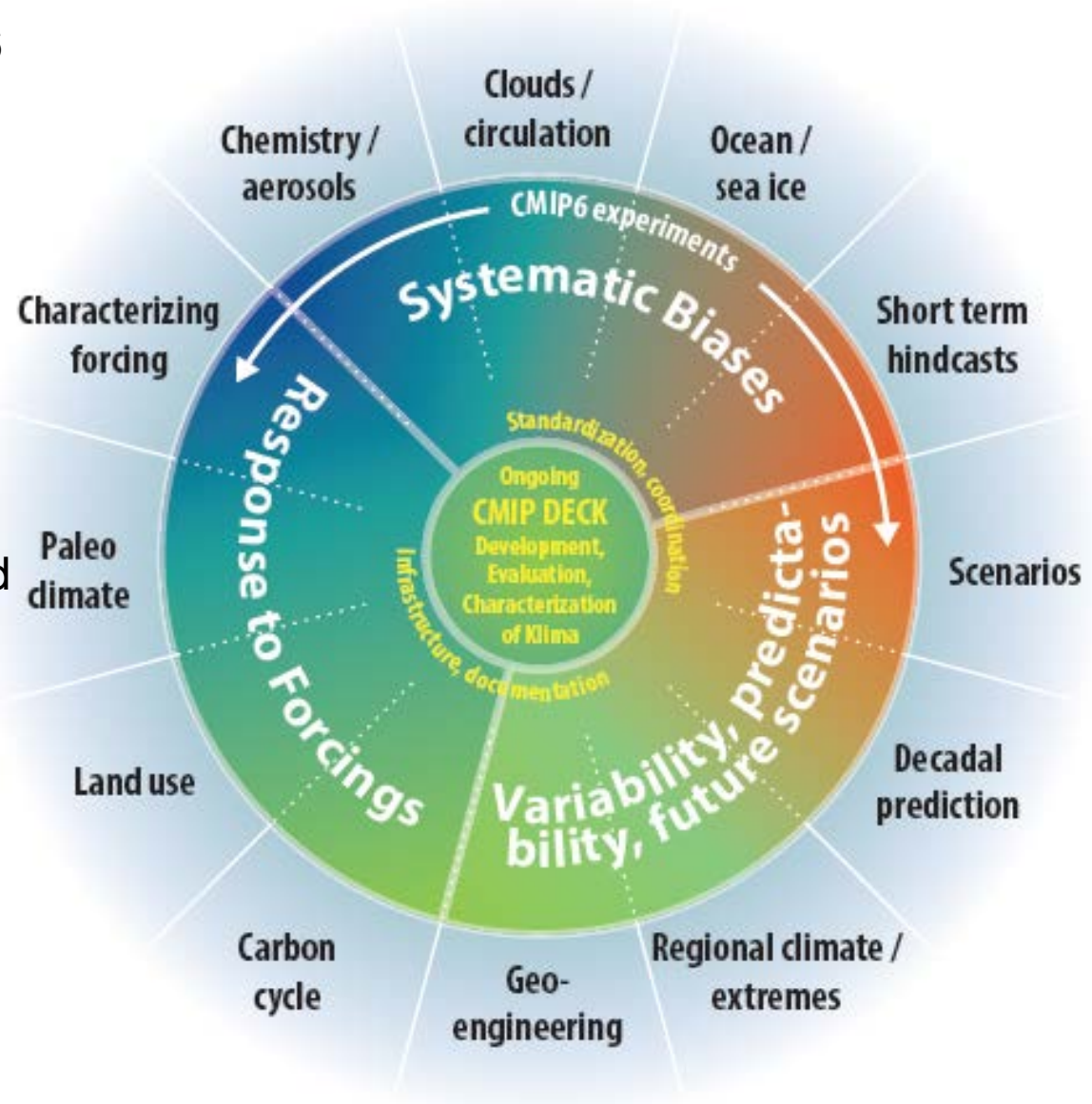
LUMIP Timeline

- 2013 Summer: Concept
- 2013 Fall: CMIP Proposal, WGCM Briefing
- 2014 Spring: GLP Meeting, Workshop 1
- 2014 July 18-19: GEWEX – Biogeophysics
- 2014 July 22-23: Hamburg – Biogeochemistry
- 2014 August 5-9: AGCI Aspen Joint-MIP Workshop
- 2014 September 15: LUMIP proposal due
- 2014-2017: Diagnostics, new scenarios, new data sets, experimental design
- 2018-2019: Model results and synthesis
- 2020: WG1 AR6 Report published

CMIP6 planning

Terrestrial processes in CMIP6

- LUMIP, C4MIP, ScenarioMIP likely to contain aspects that address land role in and response to climate change
- Pushing for land-only simulations; with/without land use change
- Are there critical land-focused science questions that were not dealt with in CMIP5 and could fall through cracks again?



Priorities for CMIP6 (Land Use)

1. Repeat and mature the LUH process (more data, more terms, increased resolution, longer period, better communication)
2. Work to standardize products, and usage of products
3. Focus: links between LU change, LC change, C fluxes, Biophys.
4. New emphasis: LU management, policy relevance, uncertainty
5. New scenarios
6. Expand RCP-RF definition to include biogeophysical, characterize RF attributed to land use in ESMs
7. Joint harmonization of LU emissions and LU changes
8. Increased emphasis on development/utilization of metrics to assess uncoupled and coupled model response to land-use change
9. Prepare for fully coupled human-physical models

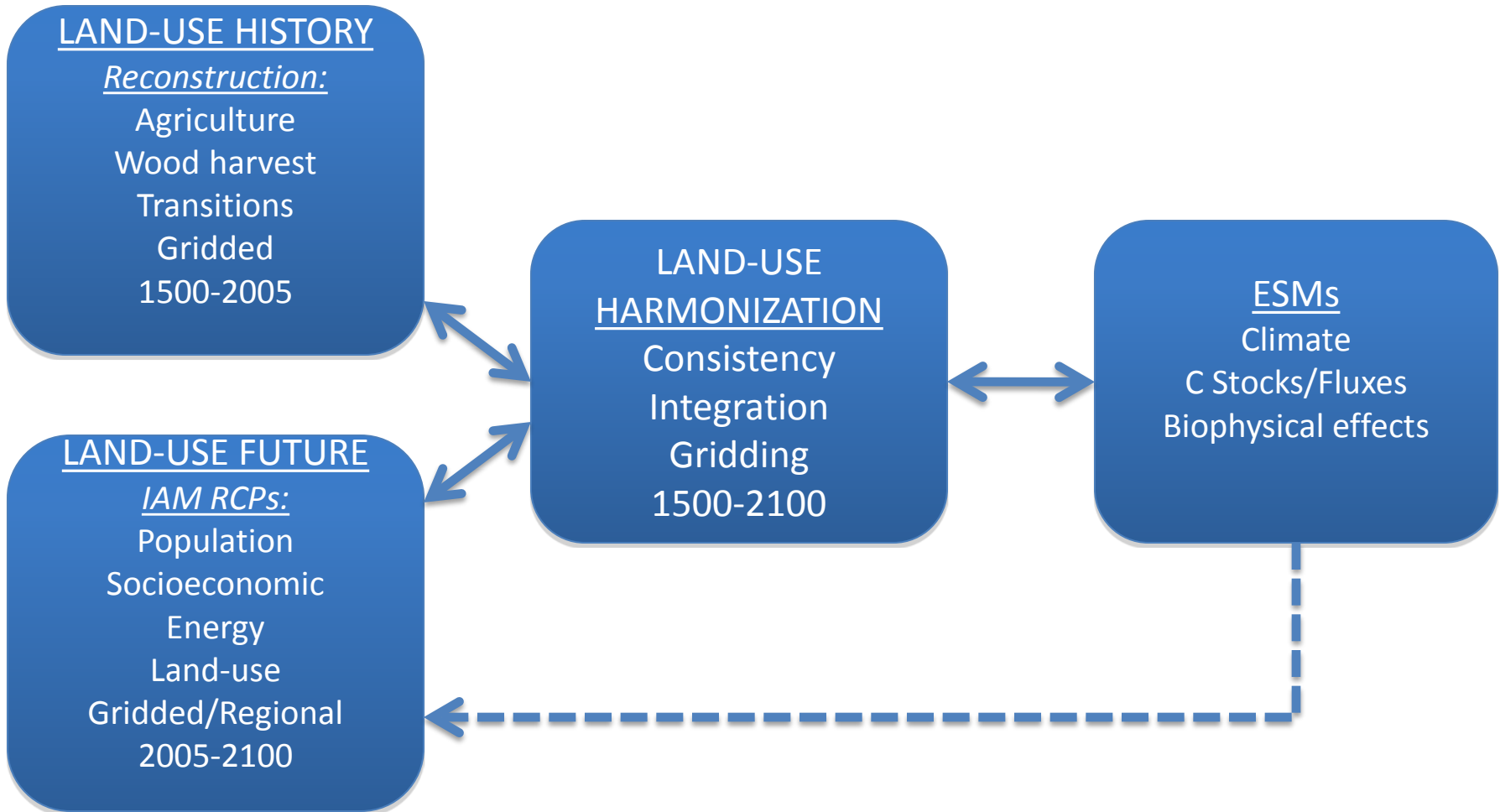
Questions (CMIP5)

- What are the combined biogeochemical and biogeophysical effects of land-use change on Earth System dynamics (past-future)?
- How can data from multiple time periods, sources, quantities etc. best be combined into a common coherent product to satisfy community modeling needs?

What was achieved (LUCID/CMIP5)?

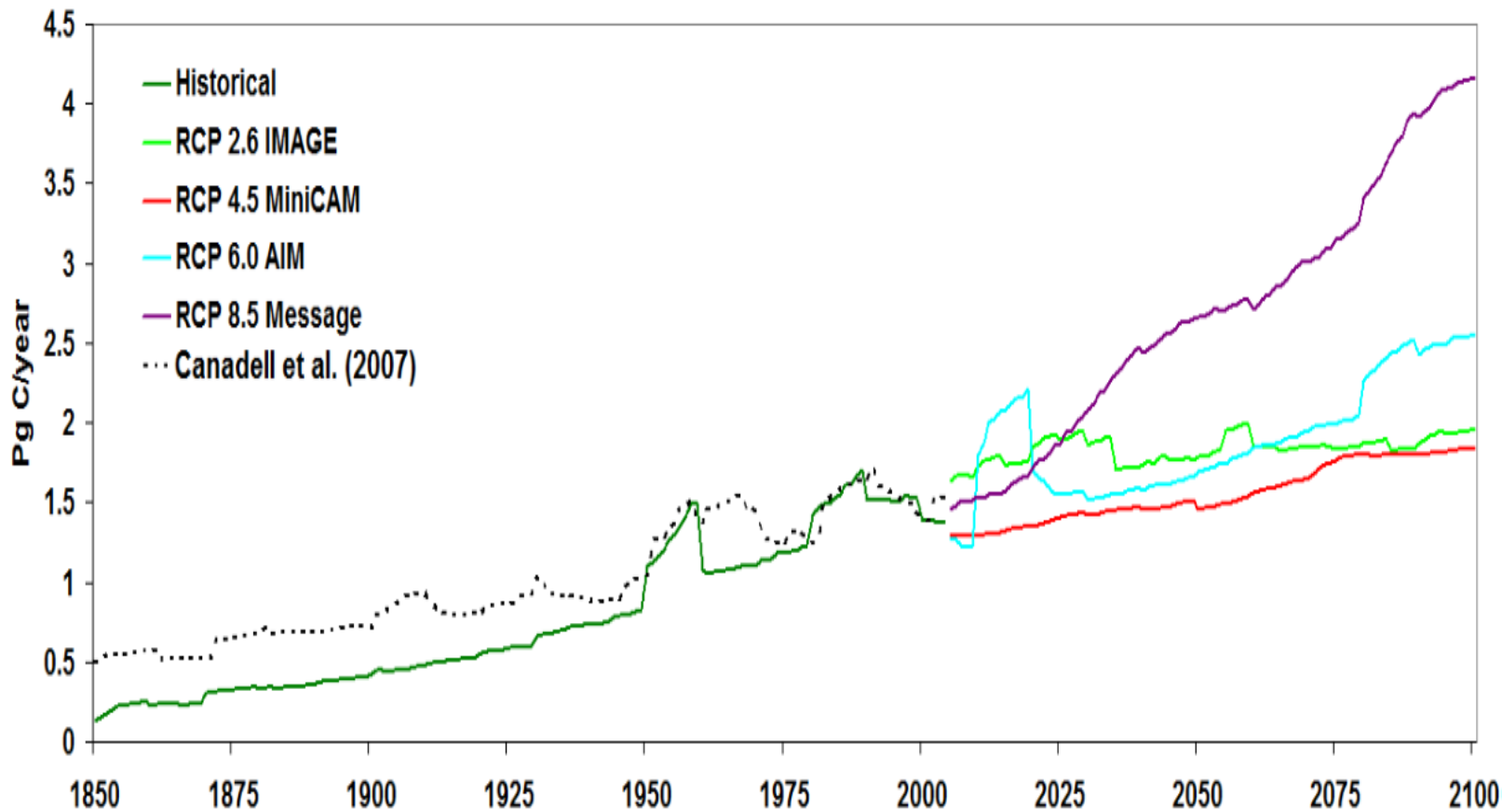
- Gridded historical and projected land use datasets developed
- Harmonization of historical and projected periods
- Historical and projected land use utilized in most CMIP5 models
- Enabled first global model projections of both carbon and climate including land-use effects

Land-Use Scheme (CMIP5)



Results from LUCID/CMIP5

LULCC carbon flux to atmosphere



CMIP6 planning

WCRP Grand Challenges

(1) Clouds, circulation and climate sensitivity

(2) Changes in cryosphere

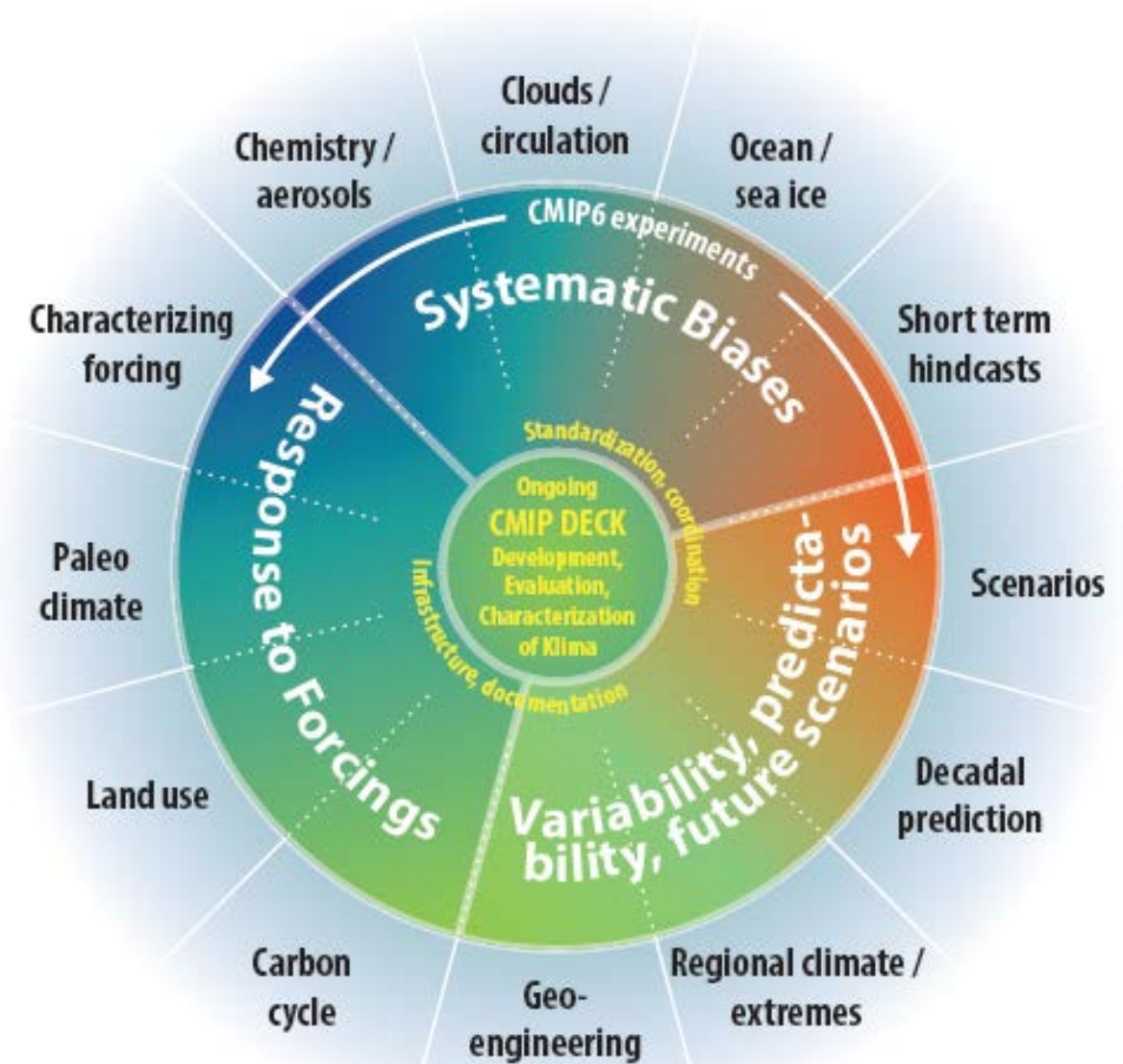
(3) Climate extremes

(4) Regional climate information

(5) Regional sea-level rise

(6) Water availability

plus an additional theme on “biospheric forcings and feedbacks”



CMIP6 timeline

2014 2015 2016 2017 2018 2019 2020 ...

Diagnostic, Evaluation and Characterization

with standardized metrics & assessment

CMIP DECK

Model Version 1

Model Version 2

Model Version 3

Model Version 4

CMIP6 Endorsed MIPs

MIP1

MIP2

MIP3

MIP1

MIP4

MIP2

Finalize experiment design (WGCM)

Scenario MIP studies, MIP matrix, pattern scaling, scenario pairs

Community input on CMIP6 design

Formulate scenarios to be run by AOGCMs and ESMs

Forcing data: harmonization, emissions to concentrations

Preliminary ESM/AOGCM runs with new scenarios

Run and analyze scenario simulations from matrix

Possible IPCC AR6

Future projection runs

Nominal Simulation Period of CMIP6

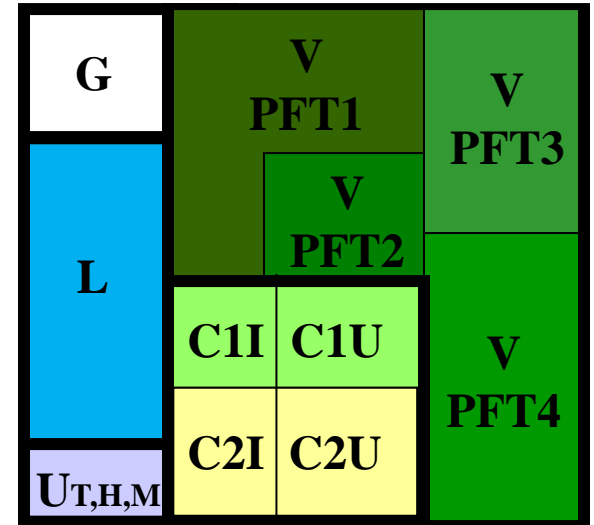
LUMIP Major Activities

- **Vertical integration and coordination**
 - Historic and projected land use dataset generation and harmonization
 - Consideration of additional land management information
 - Development/application of land-use metrics
 - Coupled and offline experiments focused on land use for CMIP6 (idealized and scenarios)
- **Benefits**
 - CMIP6 endorsed MIPs can make full use of the ESGF infrastructure
 - Standardization of land-use variables / model output format

Gridcell



CLM subgrid tiling structure



Landunit



Vegetated



Lake



Urban

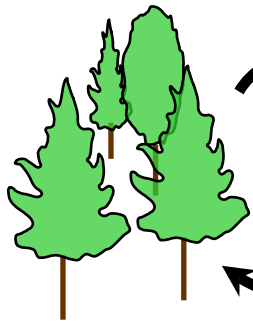


Glacier



Crop

Crop Model



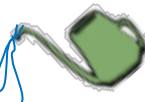
Land Use Change



Planting



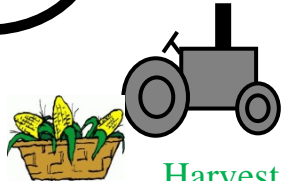
Leaf emergence



Irrig / Fertilize



Grain fill



Harvest



Unirrig



Irrig



Unirrig



Irrig



Crop1



Crop1



Crop2



Crop2 ...

LUMIP Science Questions

- What are the effects of land use and land-use change on climate (past-future)?
- What are the effects of climate change on land-use and land-use change?

*Additional detailed science questions to get at process level attribution, uncertainty, data requirements, etc.

*Particular focus on uncertainty, and separating effects of: fossil fuel vs. land use, biogeochemical vs biophysical, land cover vs land management.