# State of CLM Update

David Lawrence and LMWG

NCAR is sponsored by the National Science Foundation

# Welcome …

Consider new ideas
Encourage innovation
Offer constructive feedback
Acknowledge teamwork
Show appreciation
Share the air

CGD
Climate & Global Dynamics
a Laboratory of NCAR

# LMWG Andrew Slater Award

The award will be given out annually for the "best student or postdoc performance" at the meeting. We hope that this award will help us all to remember the special way that Drew went about being a scientist and further that it will inspire young scientists to follow in his footsteps. Drew's way included a dedication to deep understanding of his research topics from theoretical, observational (fieldwork) and modelling angles, and also involved a certain irreverence for the status quo.

# LMWG Andrew Slater Award

2018 Recipients

Marysa Laguë
University of Washington

Daniel Kennedy
Columbia University

# The Land Model Working Group

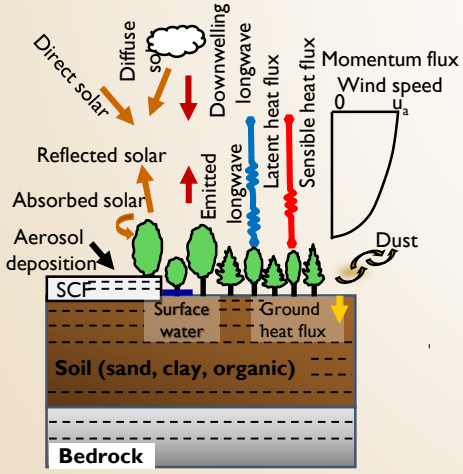
# Andrew Slater Award

Is hereby granted to:

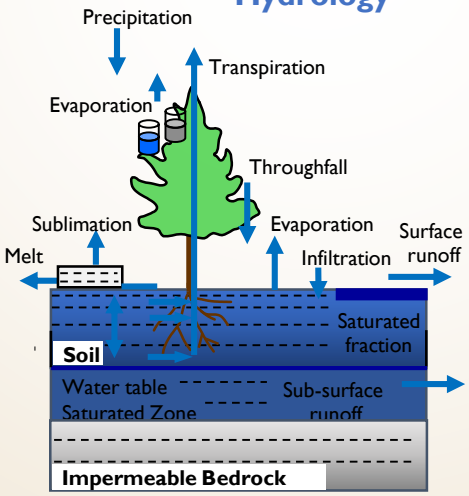
???

for best student or postdoc performance at 2019 LMWG Workshop

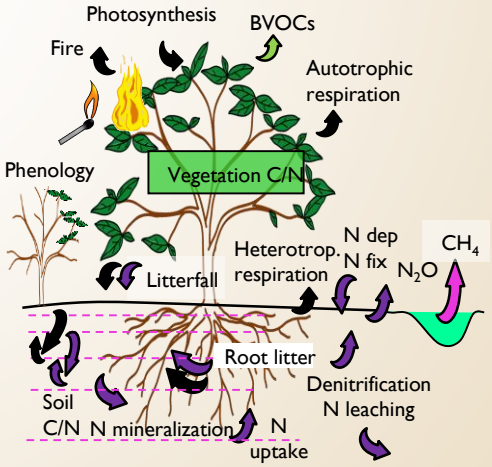
**Surface energy fluxes**

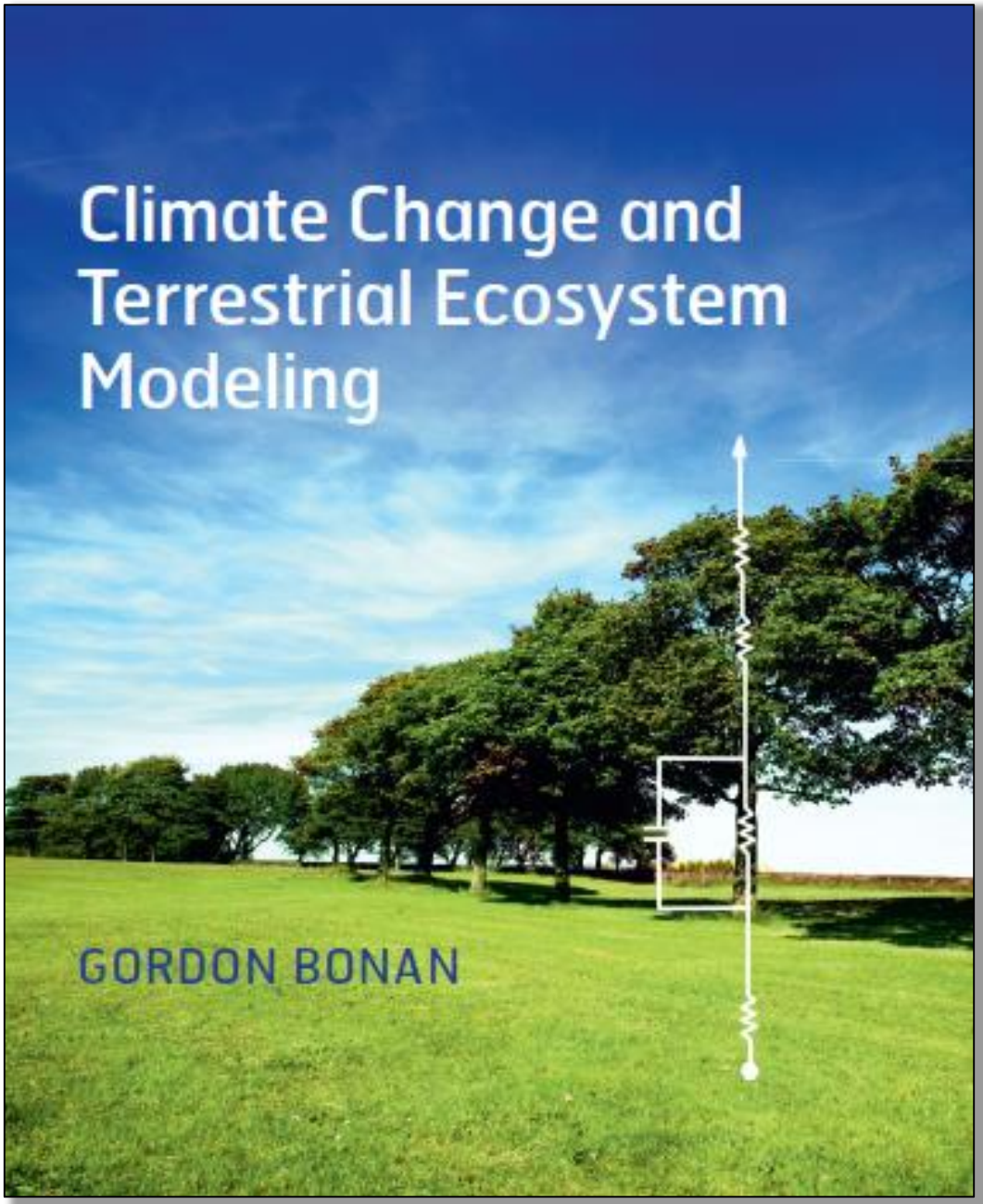



**Hydrology**




**Biogeochemical cycles**






## Preface

Writing a modeling textbook is daunting.

… Why would one undertake such a task?

Available in the US in April and in the UK in February

Tweets 355 | Following 271 | Followers 535 | Likes 249

# CLM_science

@CLM_science

Community Land Model matters: development, publications, ideas, inspiration, etcetera

cesm.ucar.edu/models/cesm2/l…

Joined August 2015

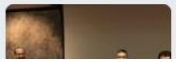
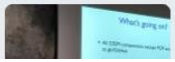
Tweet to CLM_science

1 Follower you know

NCAR SCIENCE

13 Photos and videos




Tweets | Tweets & replies | Media

Pinned Tweet

**CLM_science** @CLM_science · 14 Sep 2018

Exciting times. #FATESmodel development is now fully public at github.com/NGEET/fates Tell all your friends!


**NGEET/fates**

repository for the Functionally Assembled Terrestrial Ecosystem Simulator (FATES) - NGEET/fates

github.com

24 30

**CLM_science** @CLM_science · Feb 8

FATES tutorial today, broadcast online here:.

**2019 CTSM Tutorial**

The National Center for Atmospheric Research is offering a week-long tutorial on the Community Terrestrial Systems Model hosted by the Climate & Global Dynam...

cgd.ucar.edu

# CTSM and FATES Tutorial
# lectures and practicals online

# CLM5 documentation papers for CESM2 special issue

| | | |
|---|---|---|
| CLM5 model overview and technical description | Lawrence et al. | In review JAMES |
| CLM5 C-N Parameter Uncertainty | Fisher et al. | In review JAMES |
| N and $CO_2$ fertilization | Wieder et al. | In review GBC |
| Carbon cycle uncertainty | Bonan et al. | In review GBC |
| CLM5 Crop | Lombardozzi, Lu et al. | In review JGR-Biogeo |
| Urban model | Oleson et al. | In review JAMES |
| Plant Hydraulic Stress | Kennedy et al. | Published JAMES |
| CLM5 Land cover | Lawrence, P et al. | In prep JAMES |
| CLM5 LULCC | Lawrence, P et al. | In prep JAMES |
| CESM2 Overview | Danabasoglu et al. | In prep JAMES |
| Land-atmosphere interactions | Swann, Lague, Kumar et al. | |
| Land in coupled system | ??? | |

# Bugs

# ESCOMP / ctsm





22 Open 9 Closed Author Projects Labels Milestones Assignee Sort

- **QSNOEVAP history output incorrect** type: bug - impacts science — 5
  #624 opened 19 days ago by olyson
- **Odd (blocky) spatial patterns in generic crop leafc for BGC simulation when initialized from BGC-Crop** type: bug - impacts science — 8
  #608 opened on Jan 8 by olyson
- **All cases use modern atmospheric CH4 even for pre-industrial or transient cases** type: bug - impacts science — 4
  #604 opened on Jan 4 by ekluzek
- **Use of C13/C14 timeseries for non-transient control cases gives incorrect input when run long enough** type: bug - impacts science
  #592 opened on Dec 10, 2018 by ekluzek cesm2.1.1
- **Snow depth increase due to inconsistent snow cover fraction calculation** type: bug - impacts science — 4
  #573 opened on Nov 23, 2018 by kjetilaas
- **Antarctica ice shelves are being treated as wetlands rather than glaciers** type: bug - impacts science — 9
  #545 opened on Oct 25, 2018 by billsacks cesm2.1.1
- **irrigate in 1850 is off for runs with use_crop but on for those without** type: bug - impacts science — 8
  #509 opened on Sep 12, 2018 by billsacks

# C allocation to uptake responds to $CN_{uptake\text{-}cost}$ and $CN_{actual}$

Adjustment factor

FUN equation

$$Cnuptake = C_{adj} \times \frac{(GPP\text{-}MR)}{(CN_{target} / CN_{uptake\text{-}cost}) + 1.0}$$

C:N < target C:N

$$C_{adj} = 1.0 - (CN_{uptake\text{-}cost} - P_a) / P_b$$

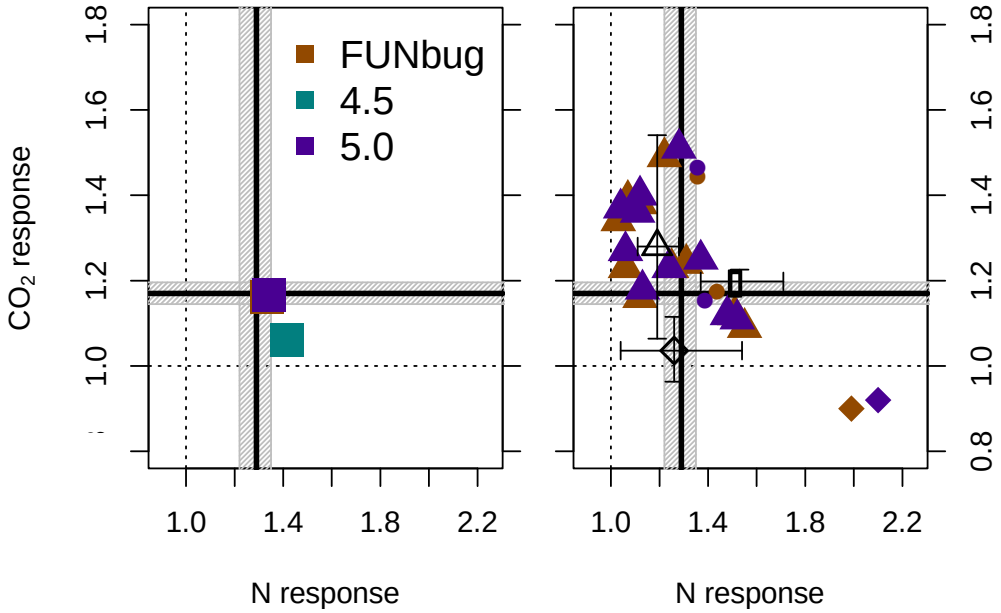
Reduce C allocation with cost

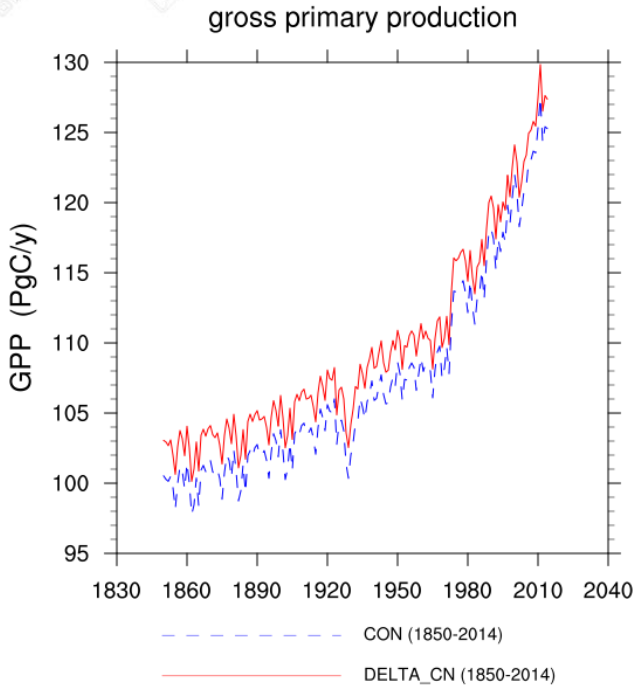
C:N > target C:N

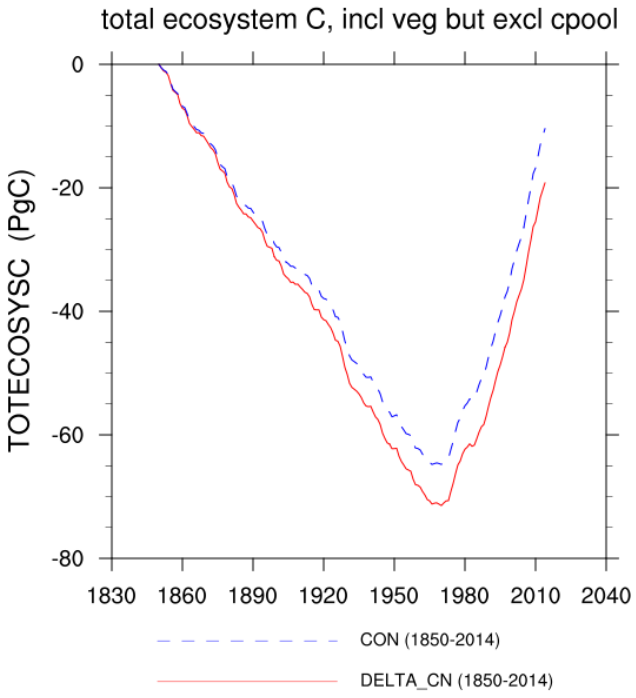
$$C_{adj} = C_{adj} + (1.0 - C_{adj}) \times (CN_{actual} - CN_{target}) / P_c$$

Increase C allocation with high C:N

# Impact

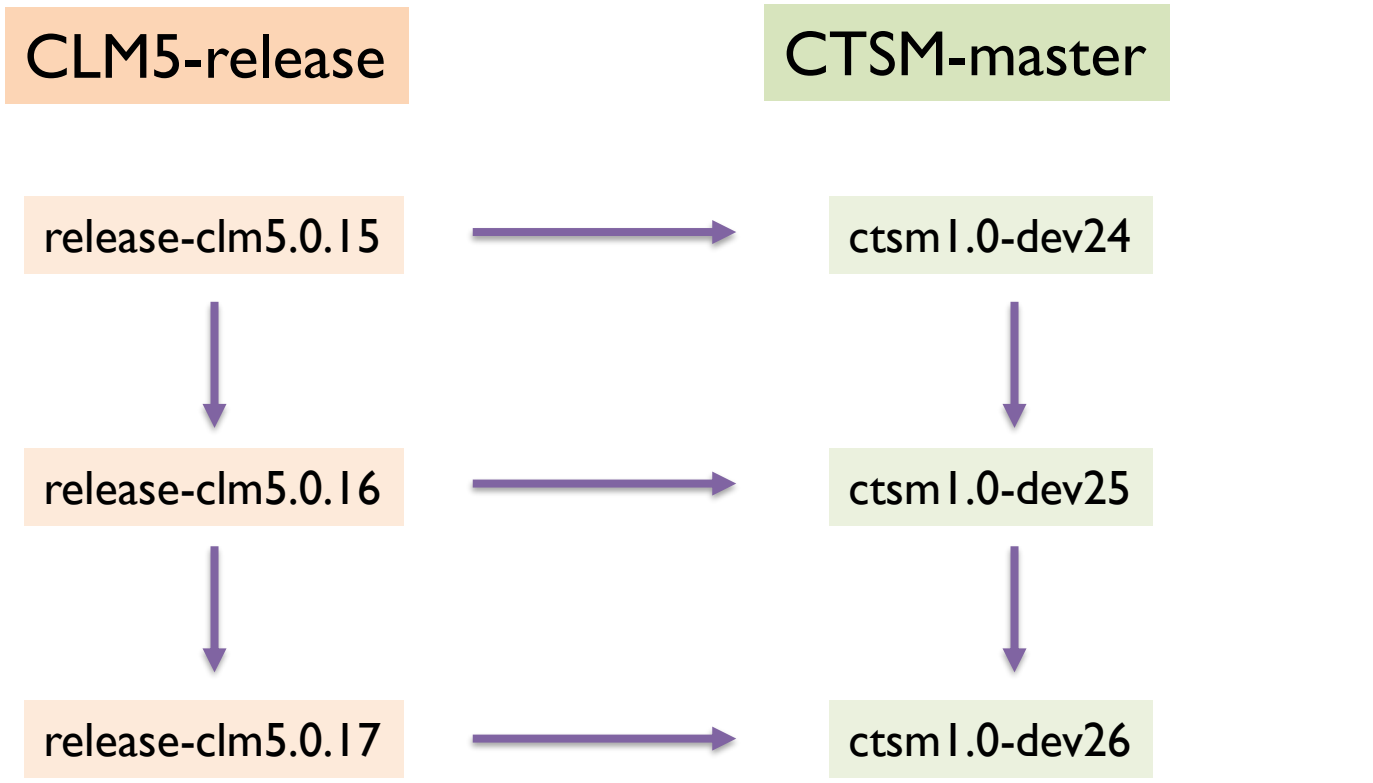



Impact is relatively small
Full assessment and documentation underway

# Code development procedure




Only answer-preserving or CESM agreed answer-changing bug fixes

Long-term development, CLM5 'simulated climate' maintained

Significant answer changes would go under a switch

# Active development projects

- FATES – many projects (Rosie Fisher, Charlie Koven, Jackie Shuman, Ryan Knox and many others
- Representative hillslopes (Sean Swenson, Martyn Clark, Dave Lawrence)
  - Slope, aspect, gaining/losing streams
  - Input datasets to characterize dominant hillslope(s)
- Water tracers (isotopes), hydrology code refactor (Bill Sacks)
- Multi-layer canopy (Gordon Bonan)
- C and N matrix solution (C residence time, attribution of C dynamics to processes) (Chris Lu, Yiqi Luo)
- Water management
  - mizuRoute – network based river model (Naoki Mizukami, Martyn Clark), coupling to CIME, lakes
  - Dynamic lake area (inne Vanderkelen, Bill Sacks)
  - Reservoir management (Inne Vanderleken, Wim Thiery)
  - Multiple irrigation methods (drip, sprinkler) and sources (rivers, groundwater) (Sean Swenson)

# Active development projects

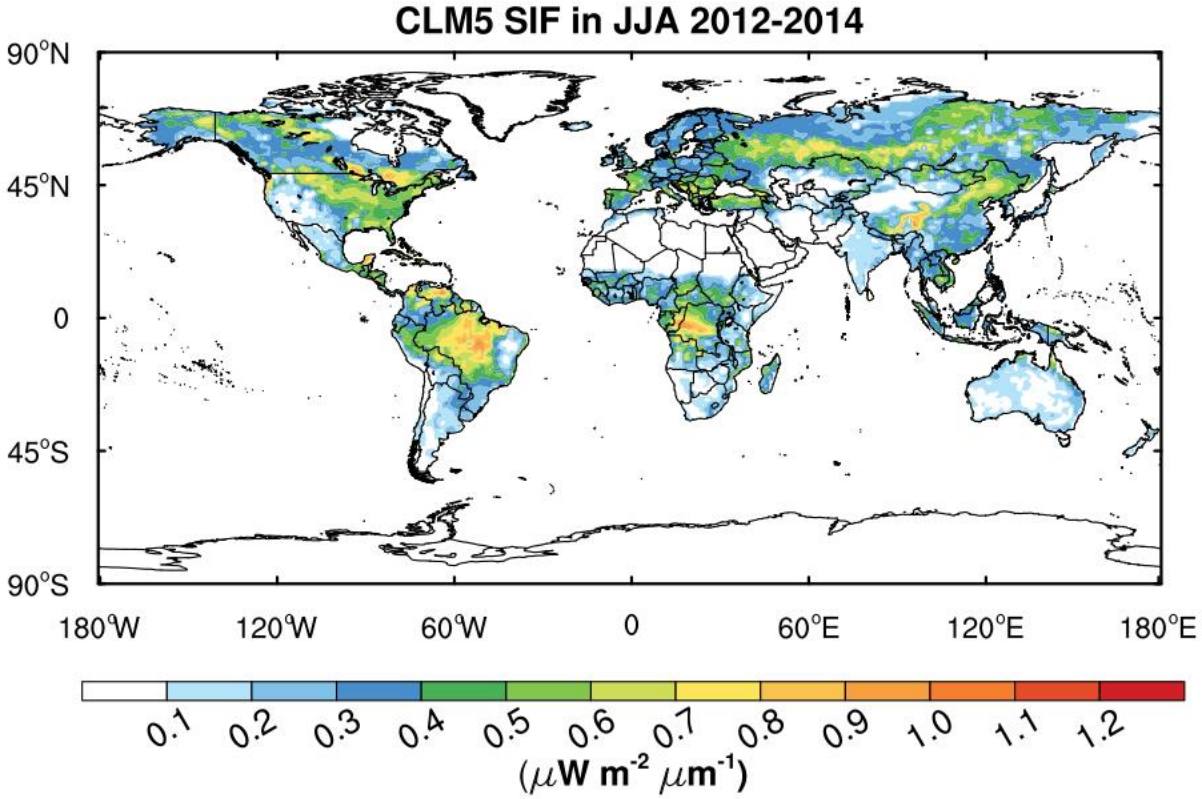
- Agriculture
  - Shifting cultivation (Peter Lawrence)
  - APSIM crop model with add'l phenological stages (Bin Peng, Kaiyu Guan)
  - Crop tillage (Michael Graham, Danica Lombardozzi)
  - Bioenergy and other crop parameterizations (miscanthus, switchgrass, oil palm) (Yanyan Chang, Maoyi Huang, Yuanchao Fan)
  - Manure and ammonia volatilization (Julius Vira, Peter Hess)
  - Specified spatially-explicit planting and harvest dates (Mike Barlage, Fei Chen, Bill Sacks)
- Solar induced fluorescence (SIF) (Mingjie Shi)
- Biomass heat storage (Sean Swenson)
- Simple land model (Marysa Lague)
- Seasonal deciduous phenology (Grace Li, Toby Ault)

- Ease-of-use development for CTSM (Sam Levis, Erik Kluzek, Negin Sobhani)
  - PFTs, parameters, flexible surface dataset generation
- LIght-weight Land-Atmosphere Coupler (LILAC)

# Active development projects

- Microbial model (MIMICS) (Will Wieder)
- Equilibrium Chemistry Approximation (ECA) for plant-microbe nutrient competition
- Parameter calibration (Katie Dagon, Rosie Fisher)

# Active development projects



# Terrestrial Processes in CMIP6

Coordinated activities to assess land role and response to climate and climate change

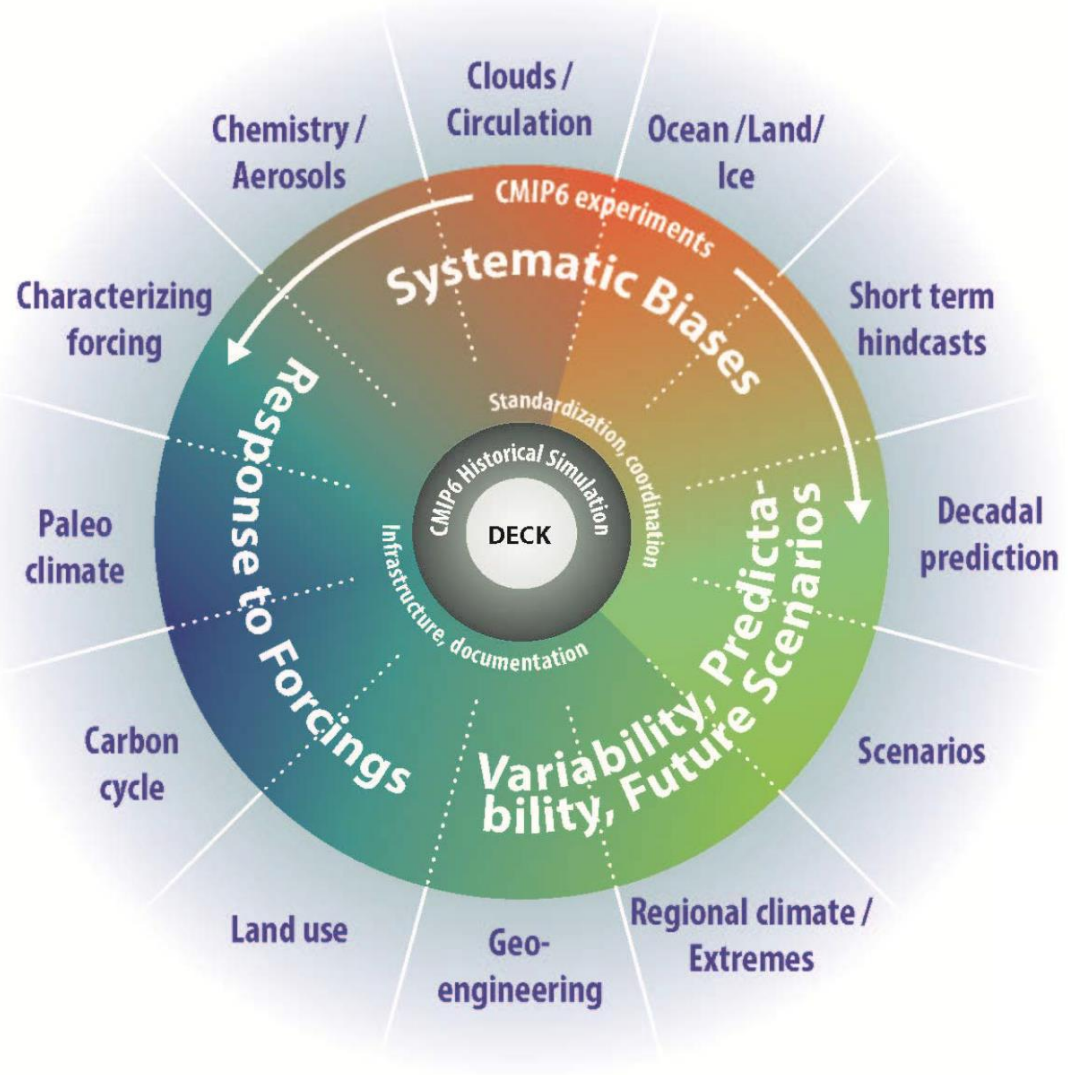
- **Land-only** simulations forced with obs historical climate, land systematic biases

- **Land Use (LUMIP)**
  land use forcing on climate and carbon, impacts of land management, land management as mitigation

- **Water, Land-atmos (LS3MIP)**
  biogeophys feedbacks including soil moisture and snow feedbacks

- **Carbon (C4MIP)**
  land biogeochemical feedbacks on climate, permissible emissions

- **Carbon Dioxide Removal (CDR-MIP)**




*Updated from Meehl et al., EOS, 2014*

# Land-related CMIP6 simulation status

| Experiment | Dependency | Status |
|---|---|---|
| | | |
| **DECK (PI Control, 4xCO2, 1%CO2, AMIP) + Historical** | | ✓ |
| | | |
| **LUMIP** | | |
| Idealized deforestation | PI control | ✓ |
| Historical no land use change | Historical | ✓ |
| Alternate land use SSPs | ScenarioMIP | |
| Alternate land use SSP-ESM | ESM historical | |
| | | |
| **C4MIP** | | |
| 1% CO2-BGC | PI Control | ✓ |
| SSP8.5 ESM | Historical ESM | |
| | | |
| **CDR-MIP** | | |
| 1% CO2 decline | 1% CO2 | ✓ |
| CDR-pi-pulse (ESM) | PI Control ESM (soon) | |
| | | |
| **LS3MIP** | | |
| Prescribed SM/~~Snow~~ climatology | ScenarioMIP | |
| Prescribed SM/~~Snow~~ smooth trend | ScenarioMIP | |

**Data to start being posted to ESGF by February 15**
**Many scientifically interesting Tier 2 experiments will be done with LMWG and BGCWG CSL allocations**

# Land Use Model Intercomparison Project
## land-only land management experiments

Set of land-only historic (1850 – 2014) simulations with one-at-a-time modification of particular aspects of land management

1 ✓ **Land historical all management**

2 Land historical alternate forcing data (CRUNCEP, Princeton, WATCH)

3 Year 1700 instead of 1850 start

4 ✓ No LULCC change

5 Alternate land use histories

~~6 No shifting cultivation~~

7 ✓ Crop and pasture as unmanaged grassland

8 ✓ Crops with crop model but no irrigation/fertilization

9 ✓ No irrigation

10 ✓ No fertilization

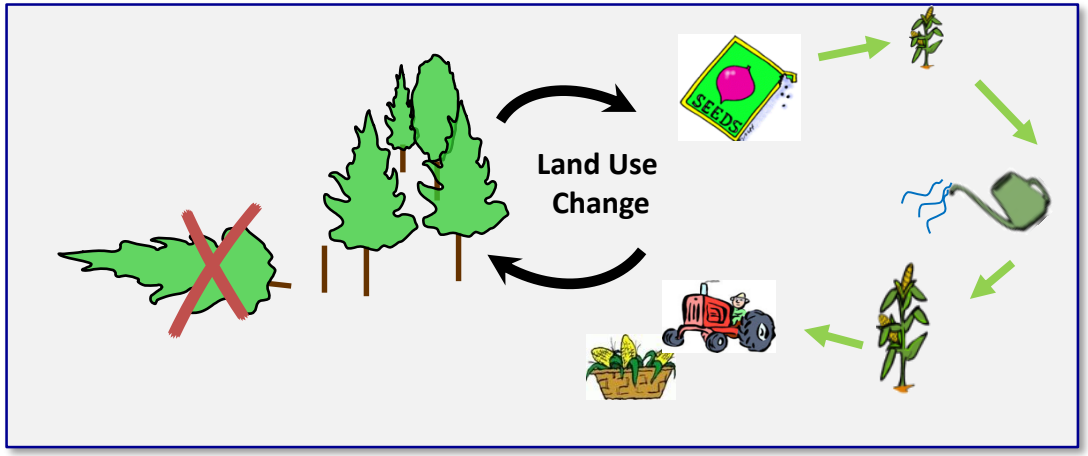
11 ✓ No wood harvest

~~12 No grazing on pastureland~~

13 No human fire ignition/suppression

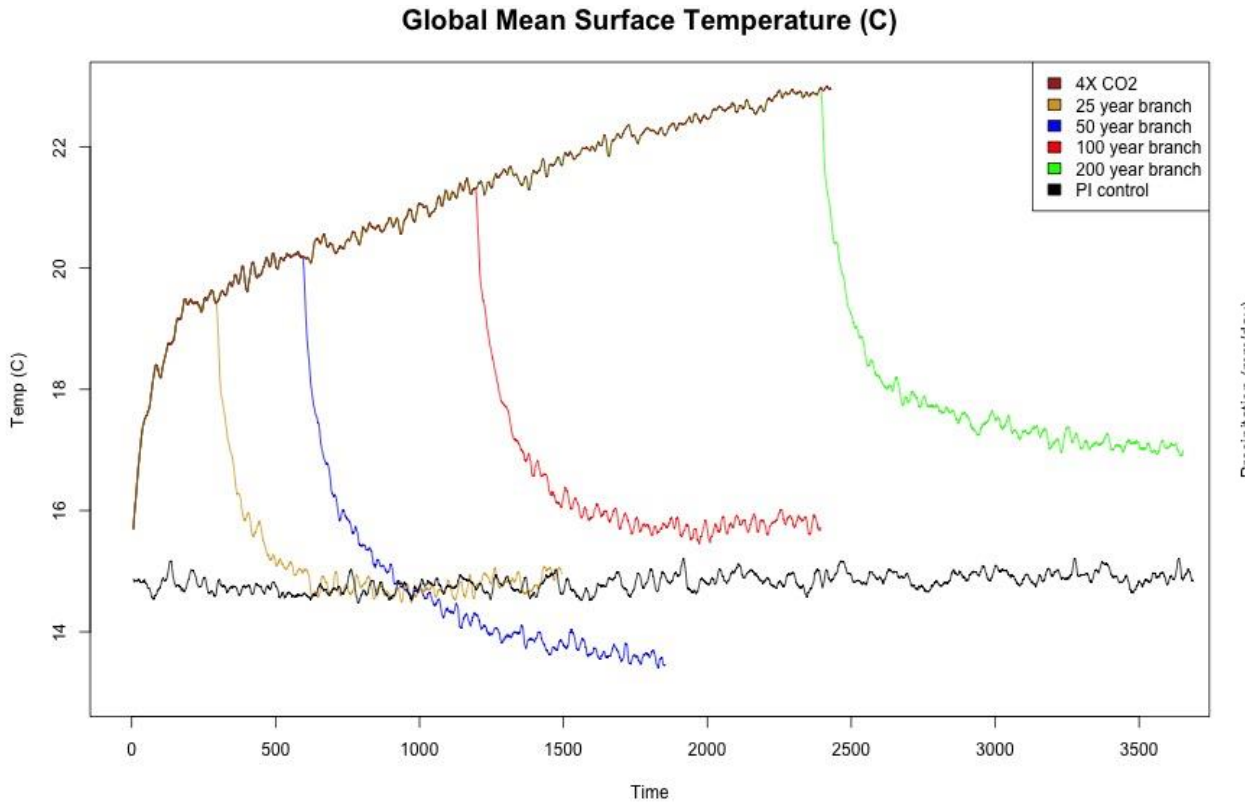
14 ✓ Constant 1850 $CO_2$

15 ✓ Steady 1850 climate




Lawrence et al., 2016

# Climate change reversibility

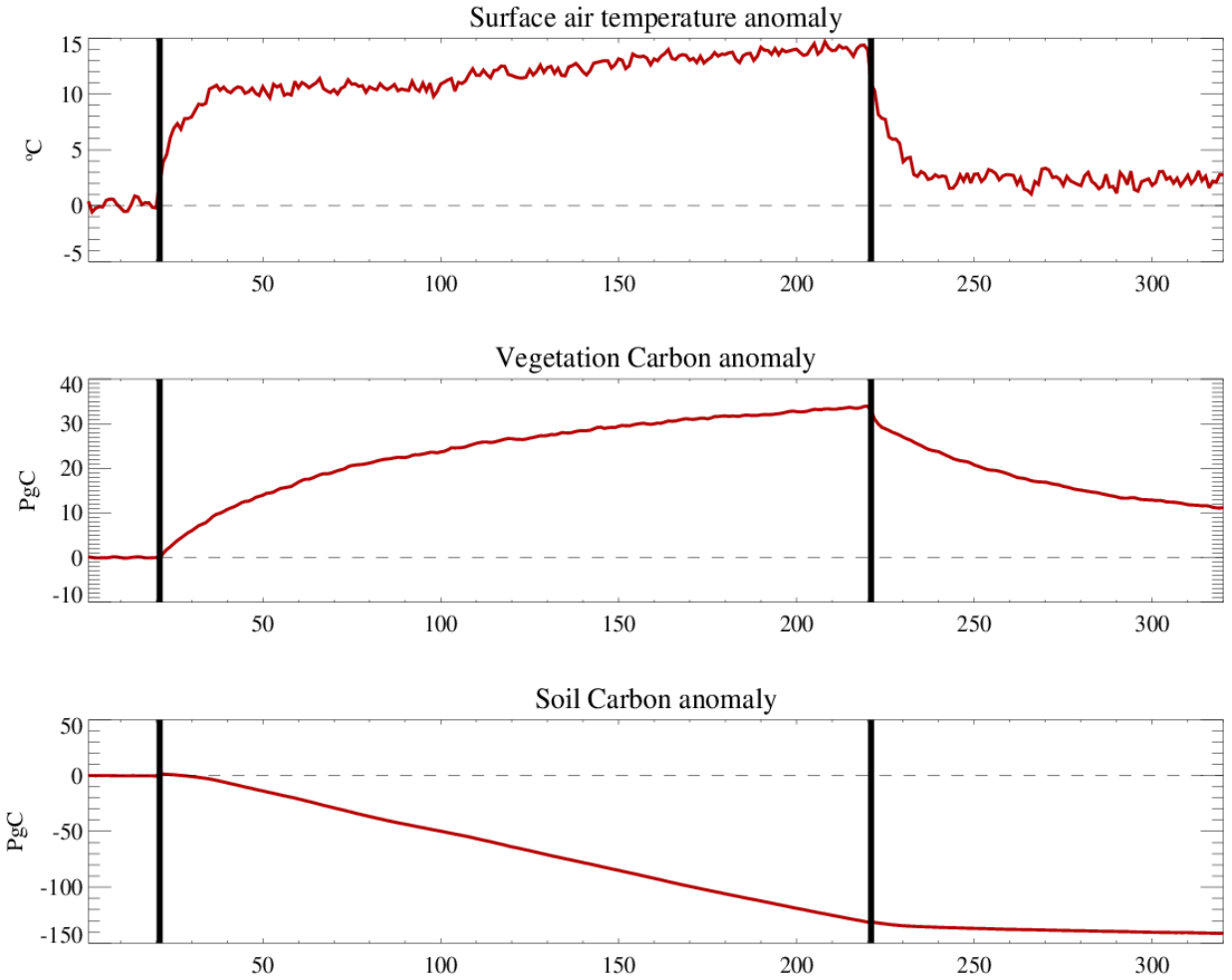



**Simulations:**

$4xCO_2$ followed by $1xCO_2$, branching from 25, 50, 100, and 200 years into $4xCO_2$ simulation

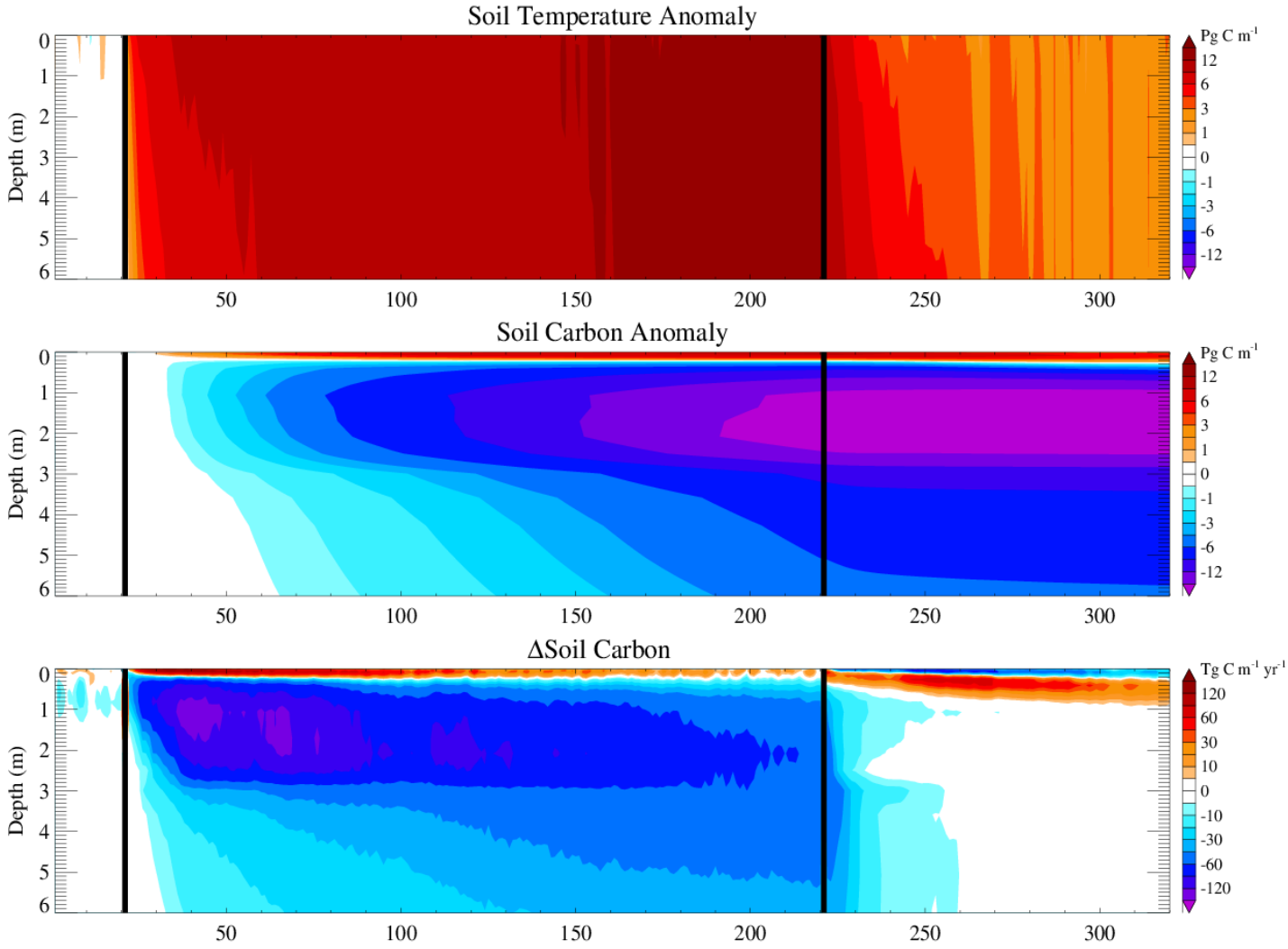
Aerenson et al., in prep

# Climate change reversibility: Permafrost carbon response



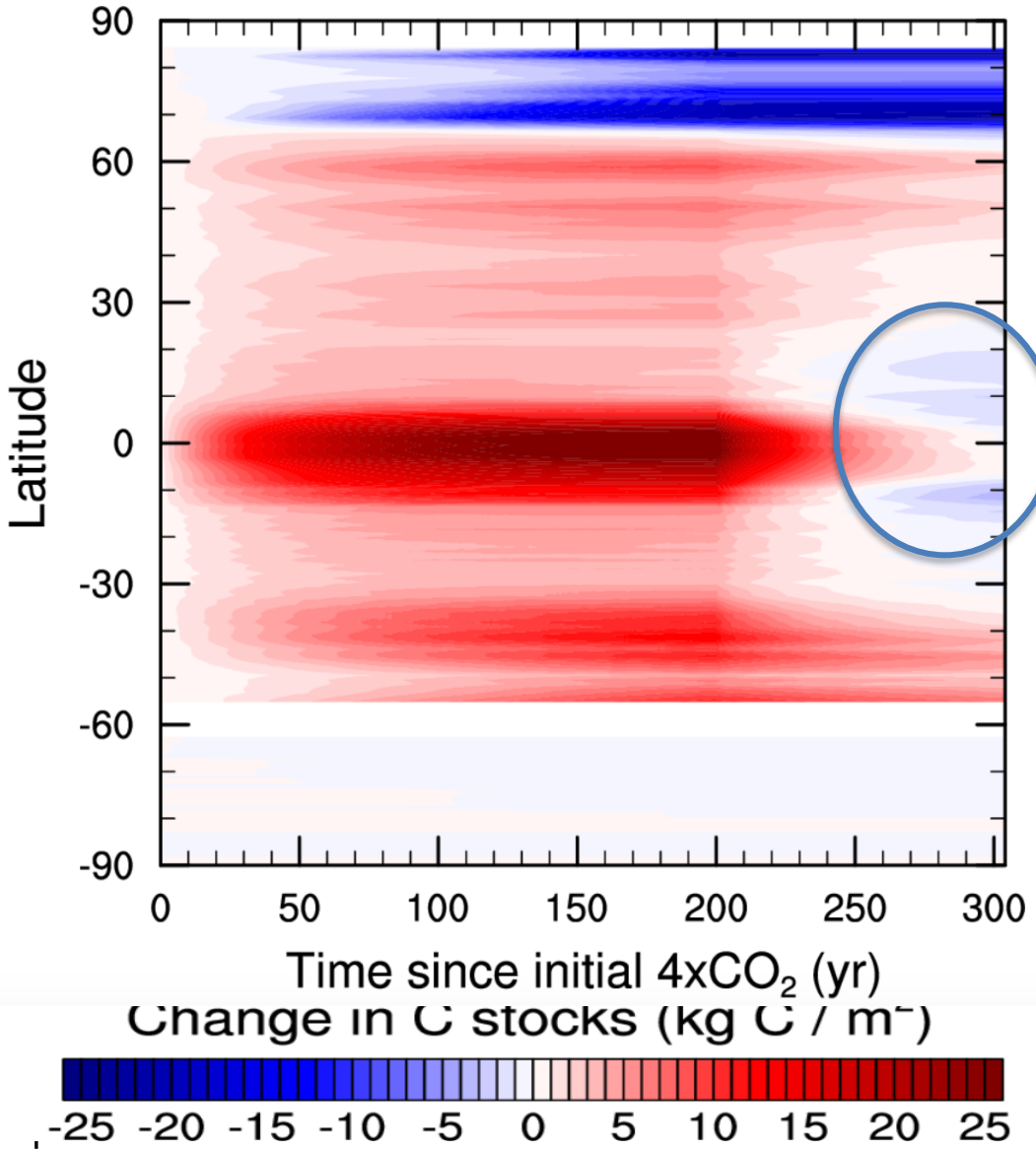

Aerenson et al., in prep

# Climate change reversibility: Permafrost carbon response




Aerenson et al., in prep

# Climate change reversibility: Global carbon response




Nitrogen feedbacks?

Aerenson et al., in

# The Large Ensembles Workshop

July 24 – 26, 2019

Boulder, Colorado

**DEADLINES**

**Abstract Submission**

Opens: January 7, 2019

Closes: March 8, 2019

**Fostering usage of large initial-condition ensembles with Earth System Models to advance understanding of natural climate variability, anthropogenic climate change, and their impacts.**

## Objectives

# Future Directions for Societal Dimensions Research in CESM

**Ben Sanderson, Kate Calvin & David Lawrence**

CESM CAB meeting, February 7 2019


## OVERVIEW

The Early Career Faculty Innovator Program is a new funding opportunity for early career faculty in the social sciences and STEM outside of NCAR's core expertise to co-develop interdisciplinary research projects in partnership with scientists and engineers at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. The Innovators Program aims to fund six faculty and one graduate student of each faculty participant for two years, starting in summer 2019. Research themes that align with NSF and NCAR strategic priorities are selected for each two-year cohort.

**2019-2020 Research Theme: Coastal Regions and Human Settlements**

Prospective applicants to the Innovators Program are invited to propose an interdisciplinary research project that can leverage expertise at NCAR and occur over a 2-year period. NCAR is committed to broadening participation in the geosciences and specifically invites scholars from Minority Serving Institutions to apply.

# CLM5 release webpage (www.cesm.ucar.edu/models/cesm2.0/land/)



# CLM5 Documentation

## Introduction

CLM5.0 is the latest in a series of land models developed through the CESM project. More information on the CLM project and access to previous released CLM model versions and documentation can be found via the CLM Web Page. Note that CLM4.5 biogeophysics and biogeochemistry can be run from this release code. A new river model (MOSART) is also included. This release is a land-only release. The capability to run CLM5.0 within CESM2.0 will be included in the CESM2.0 release.

The Functionally Assembled Terrestrial Ecosystem Simulator (FATES) is available within the CLM5 release as a research option.

## Access

- CLM5.0 is publicly available through the Community Terrestrial System Model (CTSM) git repository
- Download the code by executing the following commands:

```
git clone -b release-clm5.0 https://github.com/ESCOMP/ctsm.git clm5.0
cd clm5.0
./manage_externals/checkout_externals
```

## Documentation

- CLM5.0 Technical Description [html]
- What's new in CLM5.0 (text description), (list)

- CLM5.0 User's Guide (In development)
- Quickstart Guide (this is CESM2.0 Quick Start guide; note that same script commands used for CLM land-only)
- CIME documentation (CIME - pronounced "SEAM" - is the Common Infrastructure for Modeling the Earth provides a UNIX command-line-based interface for configuring, compiling and executing Earth system models including CLM)

# Questions or comments?

# ILAMB Assessment against CMIP5

## **Models:** Spatial metrics