ACME
Accelerated Climate Modeling for Energy

ACME Overview and ILAMB

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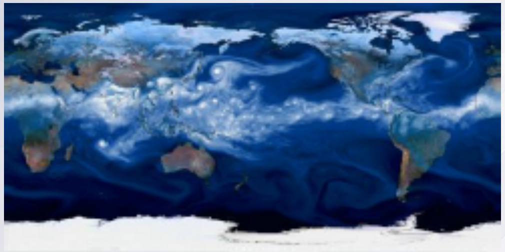
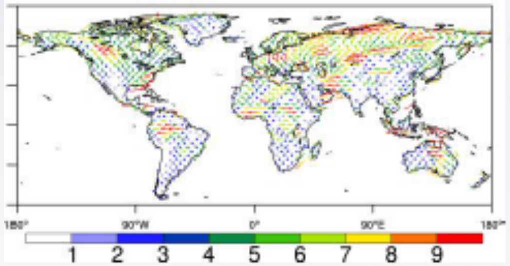
- ACME is a modeling project launched by DOE in July 2014 to develop a branch of the CESM to:
  - Advance a set of science questions that demand major computational power and advanced software
  - Provide high resolution coupled climate simulations (15-25 km), with variable resolution grids < 10km
  - Focus on near-term time horizon: 1970-2050
  - Design codes to effectively utilize next and successive generations DOE Leadership Class computers, both hybrid and multi-core, through exascale
- The project was based on a consolidation of previous DOE Laboratory model development projects, and includes 8 DOE Laboratories and 6 non-Laboratory institutions; over 100 people.
- The project is initially supported for 3 years and is structured around
  - Three science drivers and questions
  - Experiments to answer questions
  - New developments

Climate Science Drivers and Questions

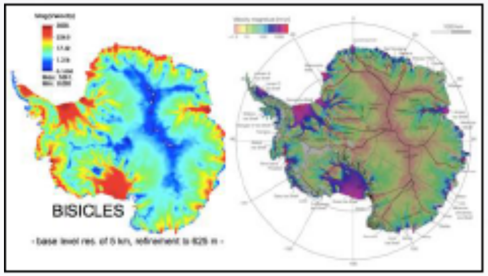
- *Water cycle:* How do the hydrological cycle and water resources interact with the climate system on local to global scales?
  - What are the processes and factors governing precipitation and the water cycle today and how will precipitation evolve over the next 40 years?



- *Biogeochemistry:* How do biogeochemical cycles interact with global climate change?
  - What are the contributions and feedbacks from natural and managed systems to current greenhouse gas fluxes, and how will those factors and associated fluxes evolve in the future?



- *Cryosphere-Ocean:* How do rapid changes in cryospheric systems interact with the climate system?
  - What is the long-term, committed Antarctic ice sheet contribution to sea level rise from climate change during 1970-2050?



New ALM Algorithms Require More Rigorous Testing

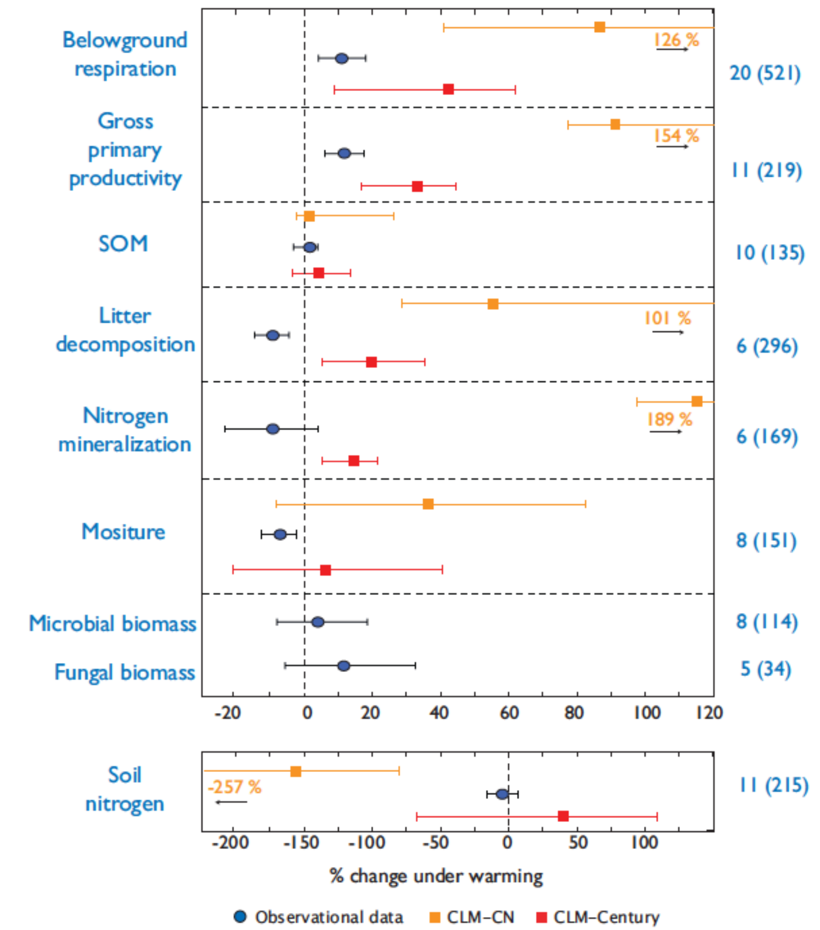
- Coupled C, N, and P cycles
  - Explicit leaf level controls on photosynthesis (Ghimire et al. 2016)
  - Multiple representations of nutrient competition (e.g., ECA (Tang and Riley 2013; Zhu et al. 2016), RD (Yang et al. 2014))
  - Dynamic allocation
- Dynamic vegetation with ED (Fisher et al. 2015)
- Vertically-resolved multi-phase, multi-tracer reactive transport (Tang et al. 2013; Tang and Riley submitted)
- Soil hydrology

ILAMB ALM Evaluation

- How should we evaluate and benchmark these much more complex models?
  - Traditional large-scale and temporal states and fluxes (e.g., LAI)
  - Site-level comparisons (e.g., Fluxnet)
  - Functional “emergent” responses (e.g., NPP vs. precipitation)
  - Functional “unit” responses
    - Manipulative experiments (e.g., FACE, nutrient addition, hydrological and temperature manipulations)
- Distinguish emergent responses from unit responses
  - Forces modular design and benchmarking
- ACME is contributing to these benchmarks

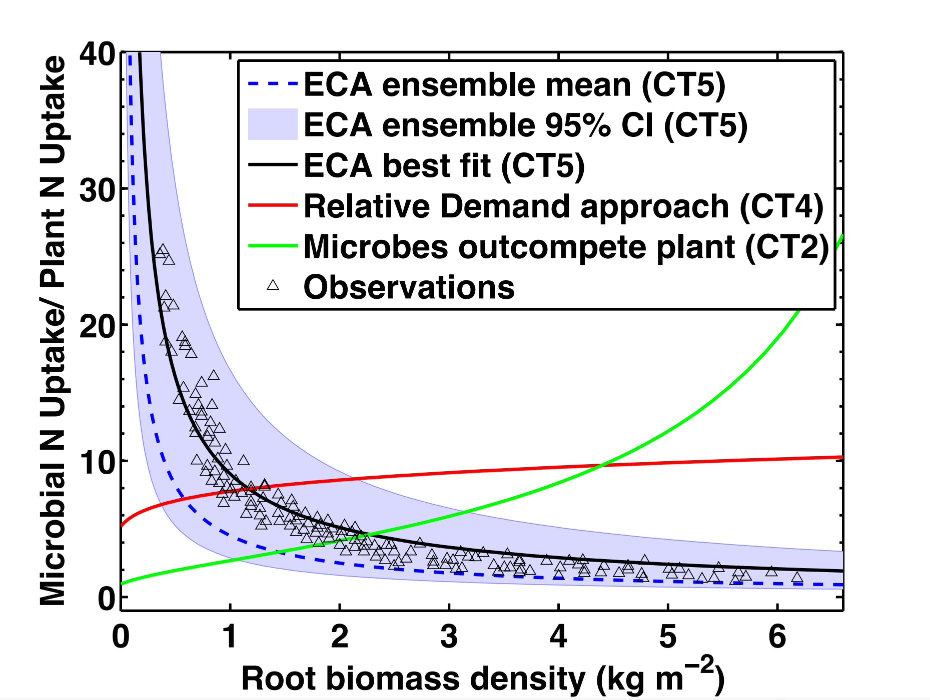
Manipulative Experiment Evaluation

Comparison with Meta-Analyses



(Bouskill et al. 2014, *Biogeosciences*)

Comparison with Individual Experiments



(Zhu et al. 2016, *in review*)

ILAMB is a Critical Component of ALM Evaluation

- Rapid model evaluation during development (Ghimire et al. 2016)
- Individual component evaluation
- Clear temporal record of model fidelity
- Facilitates comparison with other models