DOE - Earth System Modeling model development perspectives

ILAMB Workshop

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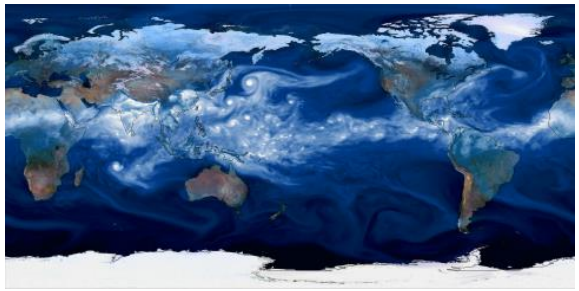
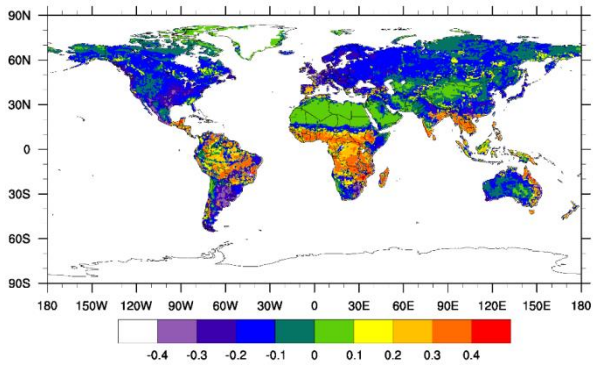
DOE's Earth System Modeling (ESM)



DOE's Earth System Modeling supports global climate model development, with particular focus on DOE science, mission, effective use of DOE computational facilities.



The DOE-SciDAC program supports computationally and mathematically advanced model development and performance

For land model development, ESM has important interactions with DOE's Terrestrial, Integrated Assessment and RGCM activities

ESM supports

a) Community projects (e.g. Hurtt et al LU-LC historical datasets for CMIP6)
b) SciDAC model development projects
c) ACME (Accelerated Climate Modeling for Energy)

Accelerated Climate Model for Energy (ACME) Overview

ACME is a global coupled climate model development project started in 2014 to develop a version of the Community Earth System Model (CESM) that will:

- **effectively use advanced DOE computational facilities, with high-resolution (1/4 degree) short time-scale emphasis (1970-2050)**
- **address Energy-mission-relevant science challenges**

ACME Science drivers, each has its own experimental design:

Water cycle: **How do the hydrological cycle and water resources interact with the climate system on local to global scales?** ***Water management and availability***

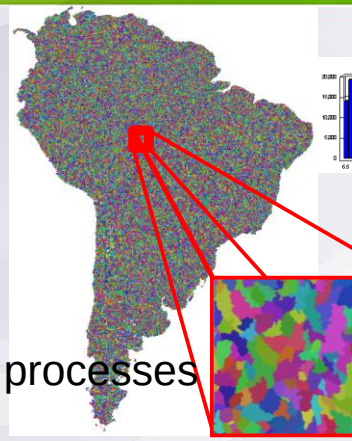
Biogeochemistry: **How do biogeochemical cycles interact with global climate change?** ***Carbon cycle – carbon exchange between land and atmosphere, effect of nutrients (C-N-P), hydrology***

Cryosphere-Ocean: **How do rapid changes in cryospheric systems interact with the climate system?** ***Sea level rise***

ACME Version 1 (v1) is frozen, to be released in 2017
Version 2 (V2) is under development

ACME
Accelerated Climate Modeling for Energy

ACME Land Model (ALM), branched from CLM 4.5



V1 – development complete

- Hydrology
  - MOSART river routing
  - VSFM soil hydrology
- Biogeochemistry
  - ECA nutrient competition model
  - BeTR reactive transport code
  - PFLOTRAN-BGC Coupling
- Vegetation
  - Dynamic rooting distribution
  - Dynamic C:N:P stoichiometry (ECA)
  - PiTS allocation
- Infrastructure/Architecture
  - UQ framework
  - Benchmarking (iLAMB)
  - Spinup acceleration
  - Point model implementation
  - Functional unit testing; modular design

V2 – under development

- Hydrology / Physics
  - Basin-sub-basin structure
  - Topographic influence on processes
  - Lateral subsurface flow
  - Variable soil depth
  - VIC runoff; Inundation dynamics
  - Stream temp, sediment, BGC, nutrient
- Biogeochemistry
  - Microbial models, minerals, $CH_{4,}$
  - Wetland biogeochemistry
- Vegetation
  - Ecosystem demography (NGEE Tropics)
  - Dynamic plant traits
  - Carbon and nutrient storage, transport
  - Plant hydraulics and mortality
- Human Dimensions
  - Water, crop Management

ESM and DOE -Terrestrial programs

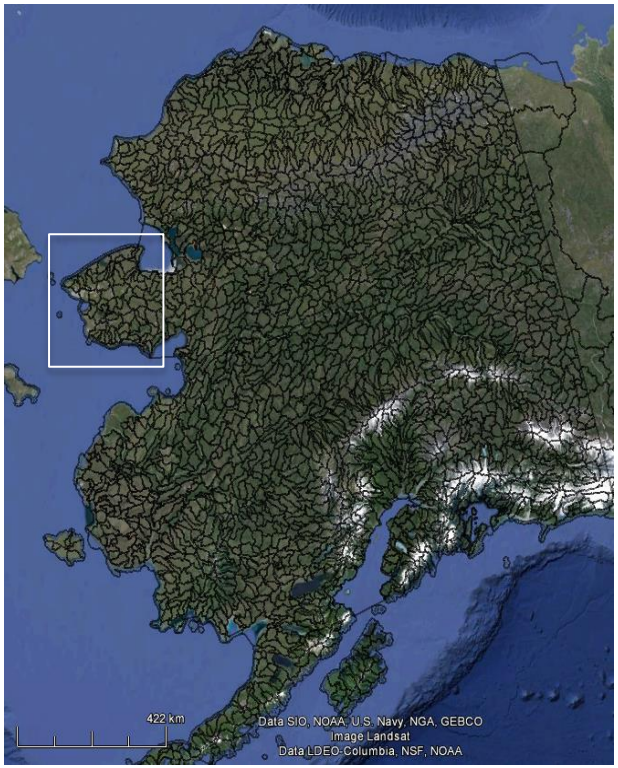
Terrestrial programs conduct field and process research/modeling, contribute to development of ACME land model

NGEE-Arctic and NGEE-Tropics use ACME-Land Model and contribute to development of:

- Ecosystem Demography
- Trait methods
- Soil biogeochemistry with C, N and P
- Coupling subsurface and plant processes
- Scaling of fine-scale hydrologic processes
- rooting schemes

Strong interest in scale issues: when and how should high-resolution processes be embedded, when parameterized?

Watershed-focused model development by subsurface projects provide high-resolution BGC-hydrology capabilities



ESM and Energy, Integrated Assessment

As a Department of Energy modeling activity, emphasis is on including human and energy interactions with the climate and land:

- Water management (irrigation, withdrawals, temperature, pollution)
- Agriculture, crops, fertilization
- Land-use, land-cover changes
- Disturbances (fire, pests, development)

With the Integrated Assessment program, consider how best to represent:

- Scenarios and energy pathways
- Impacts and adaptation

Scale issues again: when is 2-way versus 1-way coupling appropriate?

Other DOE computation and math capabilities

Modularity accommodates:

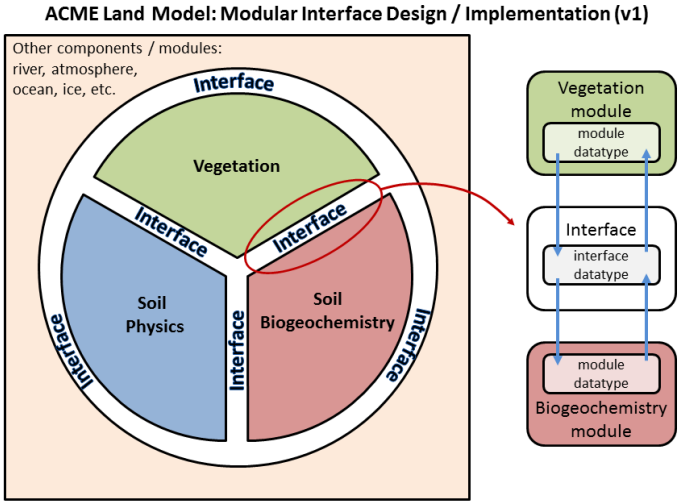
- Multiple versions
- Different levels of complexity
- Process testing

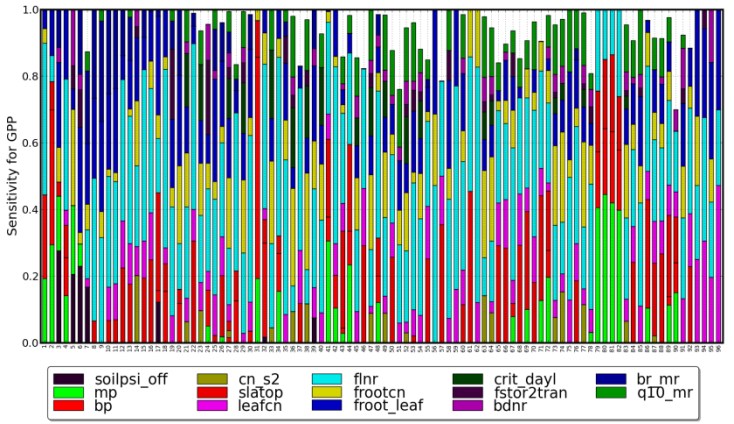
Uncertainty analysis

Model parameter calibration

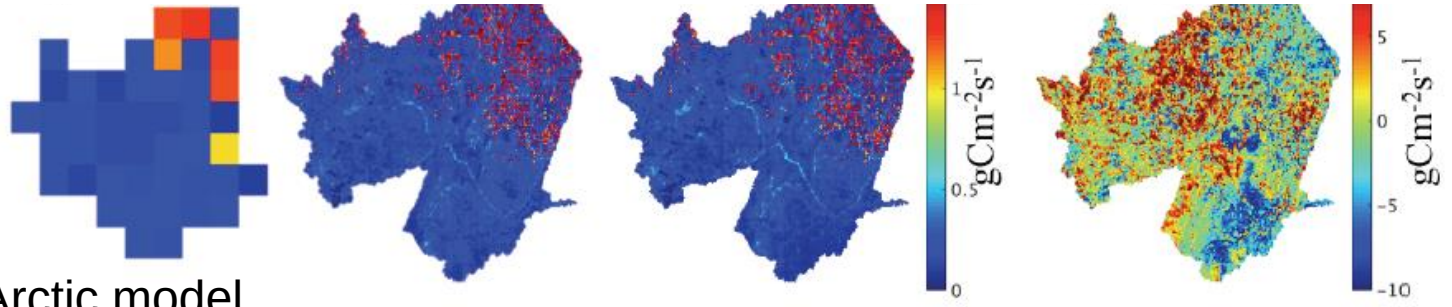
Model spin-up acceleration

Emulators, reduced-order modeling





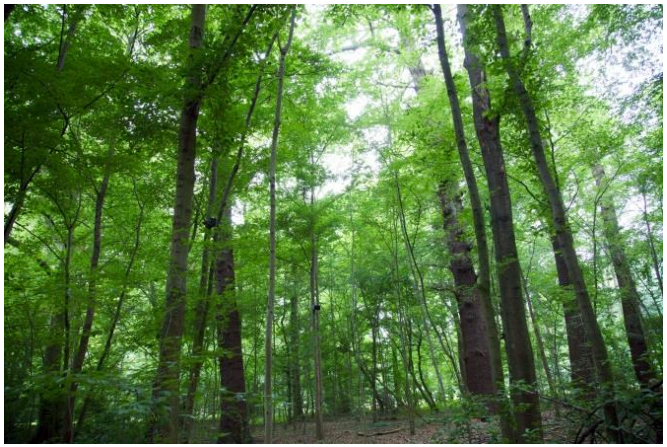
Coarse model high-resolution ROM (High-Res – ROM)

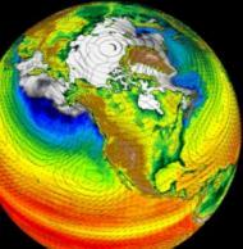


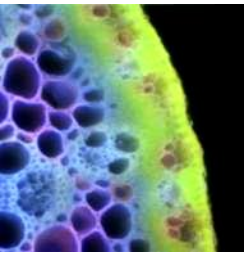
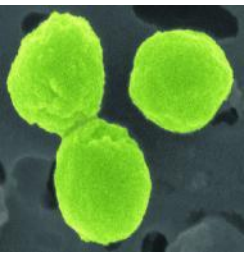
G. Pau,
NPP for Arctic model

Final thoughts

- Development groups are encouraged to share diagnostics used in their development with ILAMB community
- ACME is both using and providing diagnostic datasets to ILAMB
- ILAMB will eventually provide DOE's Ameriflux, ARM surface flux, and relevant NGEE-Arctic and NGEE-tropics datasets
- Modular development may facilitate process intercomparison or exchange





Thank you!

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ACME:
http://climatemodeling.science.energy.gov/projects/accelerated-climate-modeling-energy

Earth System Modeling:
http://science.energy.gov/ber/research/cesd/earth-system-modeling-program/