Earth & Environmental Systems Modeling

F. Energy, Water, and Land System Transitions

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Current and unique strengths and foundational capabilities of DOE?

- DOE has an extensive and expansive collection of expert groups
- DOE has facilitated a world-class, multi-disciplinary research ecosystem.
- Ability to link E-W-L landscapes across models and scales
- Ability to undertake extensive numerical experimentation
- Identify and assess key multi-sector responses
- The E3SM model can set priorities for development/coupling/linkages
- World-class HP/GPU computational systems

What are the gaps in research / infrastructure / coordination that prevent advances?

- Need for linking sectors, environments, landscapes, systems, and scales
- Need for more rigorous model diagnoses of missing critical capacities
- Need for more rigorous representation (and metrics) of human well-being.
- Cultural, social, and behavioral institutional constraints on modeling
- Theoretical/causal relationships aligned with model construction/detail?
- Can we emulate/simulate operational systems with simple models?
- Do we know what the critical model features/capacities are?
- Appropriateness/fidelity of high-resolution models and how they scale up?
- Necessary components, scaling for coupling between resource systems.

What are the grand challenges in advancing the research on this topic?

- Coupled models of environment to grid system, trade, supply chains, and resources
  - Allow for damages, impacts, and feedbacks at needed spatio-temporal scales
  - Expand stressors and trade interactions
- Community of practice: Tools that downscale and upscale(!)
- Scenario Generation-Reduction to Risk
  - Organize large sets of scenarios - on OUTPUTS
  - Filter large ensembles to run higher-order models
  - Metrics and competing objectives will give one different drivers
  - Objective determination of sample/ensemble size?
- Cultural, social, behavioral, and institutional constraints on modeling

What opportunities exist to overcome each of those gaps?

- Continue to connect natural and human systems components across our community of models
- Further coupling of weather, climate, and human system models - dynamic coupling
- Develop community tools for downscaling and aggregation
- Potential to use AI/ML for scenario reduction - subset of scenarios will be different for each end-use
- More direct engagement with the users and decision communities
- Multi-model forum(s) to address structural uncertainty, improve interoperability and reproducibility
- Use “simple” models to assess key sensitivities and guide our sophisticated models

How could the science be advanced through coordination across BER?

- Improve connections among land, water, and energy modeling systems
  - Irrigation, bioenergy, groundwater, land use trajectories, and migration/population patterns
- Creation of a unified HUC, region for land, water, and energy
- Community of practice: Tools that downscale (and upscale?)
  - Assumptions of downscaling and their sensitivities
- Create a (E-W-L)MF effort - facilitate (a multi-agency?) coordination