Acknowledgement:
U.S. Department of Energy, Office of Science, MultiSector Dynamics, Earth and Environmental System Modeling Program
Robert Vallario, Program Manager

Modeling MultiSector Dynamics
What is MSD?
Themes, Questions, and Aspirations
MultiSector Dynamics (MSD) Goal

Explore *complex interactions, feedbacks, and co-evolutionary pathways* within the integrated human-Earth system

- Natural, engineered, and socioeconomic systems and sectors
Challenge: Manage Risk in Interconnected Systems

- Global to local systems create opportunities and risks
- “...interdependent systems that we do not understand and cannot control well.” (Helbing, 2013)
- “... need to understand and thus model the pathway through which one system propagates to other interconnected systems.” (Haines, 2018)
Research Objectives

Model how sectors and systems co-evolve in response to environmental, technological, and societal transitions and shocks, including crucial Earth system feedbacks.

Represent dynamic pathways of societal change across interacting components, scales, and uncertainties.

Develop data, models and analysis methods that advance science, inform risk management, and support resilient, adaptive, and sustainable societies.
“Sector”

- A complex local-to-global system of systems that provides services and products
  - No single taxonomy
  - Components: infrastructure, environmental goods/services, technology, institutions (markets, laws, operating rules), actors, ...

- Individual studies explore different aspects and components, but most...
  - Highlight the role of infrastructure
  - Incorporate Earth/environmental systems goods and services

(Clarke et al. 2018)
“Dynamics”

- Pathways of change within and across sectors highlighting feedbacks of Earth-human systems
- Caused by a wide range of influences
  - “Shocks”—environmental and human
  - Planned initiatives to improve wellbeing (e.g., energy transitions, dynamic adaptive pathways)
- Potential for cascading impacts

(Clarke et al. 2018)
Themes and Science Questions

Dependencies & Interactions
How do sectors interact across scales? How do synergies or tradeoffs evolve?

Stressors & Uncertainties
What determines key drivers, stressors, and uncertainties? Can the path-dependencies of “failure” and “transformation” be identified?

Coupling & MSD Model Evaluation
How are key concepts defined (e.g., transformation, resilience)? What best practices are emerging for coupling and evaluation?

Modeling Adaptive Human Actions
For decision relevance, what resolution, processes, and entities are needed to represent adaptive actions and inform tradeoffs?
Community of Practice: Goals and Status
Why a Community of Practice?

Increasingly interconnected human and natural systems creates risks that we do not understand and cannot manage.

Improving modeling of the pathways in which risk propagates will improve understanding and societal outcomes.

Many research teams and communities are working on related challenges independently (both nationally and internationally).

Improved collaboration and synthesis will accelerate discovery and add value to individuals and projects.
**Inputs**

- **Principles Guiding Implementation**
  - Problem focus
  - Collaborative learning
  - Open science
  - Capacity building

**Activities**

- **Activity Areas**
  1. **Communications**
     - Website
     - Newsletters
     - Webinars
     - Professional meetings (AGU)
  2. **Conceptual framework process**
     - Scientific vision
     - Shared science questions
     - Shared aspirations for methodological advances
  3. **Coordinating and technical bodies**
     - SSG
     - Working groups
     - DOE MSD PI coordination group
     - Sponsor group
     - Facilitation team
  4. **Evaluation**
     - Document impact and improve CoP strategies

**Outputs**

- **Deliverables**
  - Community white paper and journal publication
  - “MSD-LIVE” open science platform
  - WG products addressing community challenges
  - Journal article on CoP evaluation strategy and MSD Community ‘initial conditions’

**Outcomes**

- **Near Term**
  - Increased participation
  - New participants related to defined aspirations
  - Early career researchers in visible roles

- **Medium Term**
  - Stronger identification with MSD field
  - Convergence in terminology, data, methods
  - WG products/insights applied across projects
  - Progress towards defined aspirations

**CoP Questions**

- How do scientific and decision-relevant framings of MSD research compare across projects?
- For which research questions and problems addressed is there strong potential to collaborate?
- How can different elements of a Community of Practice (CoP) be used to foster beneficial interactions that advance science?
MultiSector Impacts of Energy Transitions

Urban Systems

Human System Modeling

Uncertainty Quantification and Scenario Development

Education and Professional Development

Facilitating FAIR Data
Call for Papers at Earth’s Future

EARTH’S FUTURE SPECIAL ISSUE

Submission Deadline: 1 October 2021
AGU Fall Meeting 2021

1 DOE Town Hall (accepted)
1 MSD Union Session (accepted)
8 GEC Section Sessions (proposed)
1 Education Section Session (proposed)

For further information on MSD and how to engage:

https://multisectordynamics.org/
Thank you
For further information (CoP)

https://multisectordynamics.org/join-us/

Facilitation team: contact@multisectordynamics.org

MultiSector Impacts of Energy Transitions: stuart.cohen@nrel.gov

Human System Modeling: jim.yoon@pnnl.gov

Education and Professional Development: adyreson@mtu.edu

Urban Systems: brelsfordcm@ornl.gov

Facilitating FAIR data: casey.burleyson@pnnl.gov

Uncertainty Quantification and Scenario Development: vivek@psu.edu
For further information (DOE-funded MSD projects)

Katherine Calvin, Katharine.calvin@pnnl.gov
Andrew Jones, adjones@lbl.gov
David Judi, david.judi@pnnl.gov
Jennifer Morris, holak@mit.edu
Jennie Rice, jennie.rice@pnnl.gov
Stephanie Waldhoff, stephanie.waldhoff@pnnl.gov
Karen Fisher-Vanden, kaf26@psu.edu
For further information (sponsor)

Bob Vallario
DOE Program Manager
MultiSector Dynamics
301-903-5758
Bob.Vallario@science.doe.gov

U.S. DEPARTMENT OF ENERGY
Office of Science
BIOLOGICAL AND ENVIRONMENTAL RESEARCH
Earth and Environmental Systems Sciences

MSD
Aspirations for MSD Science

**Better capturing interdependencies and interconnectedness**

- Capture the co-evolving feedbacks between human and Earth systems
- Capture holistic suite of objectives (reliability, resilience, robustness, efficiency, equity,...)
- Capture dynamic and adaptive infrastructure systems – hierarchical modeling, incorporating new sources of data, ...
- Increase diversity of representation of human behavior

**Taking MSD science exponential**

- Innovate uncertainty characterization to ensure robust insights in increasingly complex models
- “Scale up” – extensible workflows employing emerging hardware and software tools
- Employ open science standards
- Develop MSD scientific workforce and capacity
CoP strategies

Communication
• Website
• Newsletter
• Webinars
• Outreach

Conceptual Framework/SSG
• White paper and journal article
• FT & SSG drafting
• Review process

Technical coordination
• Working groups

MSD Community of Practice