U.S. DEPARTMENT OF ENERGY | Office of Science

# PCHES: A MULTI-MODEL, MULTI-SCALE RESEARCH PROGRAM IN STRESSORS, RESPONSES, AND COUPLED SYSTEMS DYNAMICS FOR ENERGY, WATER, AND LAND

Energy, water, and land systems interact in oftentimes, complex and, as yet, poorly-understood ways — all with enormous implications for reliability of electric power supply, food security, economic productivity, international trade, changing populations and demographics, resource acquisition and utilization, and, critically, the resilience of communities and critical infrastructure to natural hazards.

With support from the U.S. Department of Energy, the Program on Coupled Human and Earth Systems (PCHES) is a leading contributor in a broad community effort to create new, state-of-the-art, integrated modeling frameworks that will drive advances in the quantitative understanding of these coupled systems. PCHES brings together a transdisciplinary team of scholars that are building the knowledge and deep analytic foundations to address these challenges and foster innovation in the emerging field of MultiSector Dynamics (MSD).

## *RESEARCH*

PCHES research spans three major focus areas that explore, analyze, and test complementary approaches to the modeling and analysis of complex multisector systems, including the many and varied influences and stressors that govern their behaviors:

1. To address questions of the impacts of extreme events on the energy-water-land system and associated adaptation options for the contiguous United States requires capturing the frequency, intensity and impacts of extreme weather events, as well as to understanding the infrastructure needs for adaptation to these events. Our approach involves coupling and testing various fine-scale process models (water balance, power system and agricultural impact models), most recently with a simplified gridded economic model (SIMPLE) of the United States.

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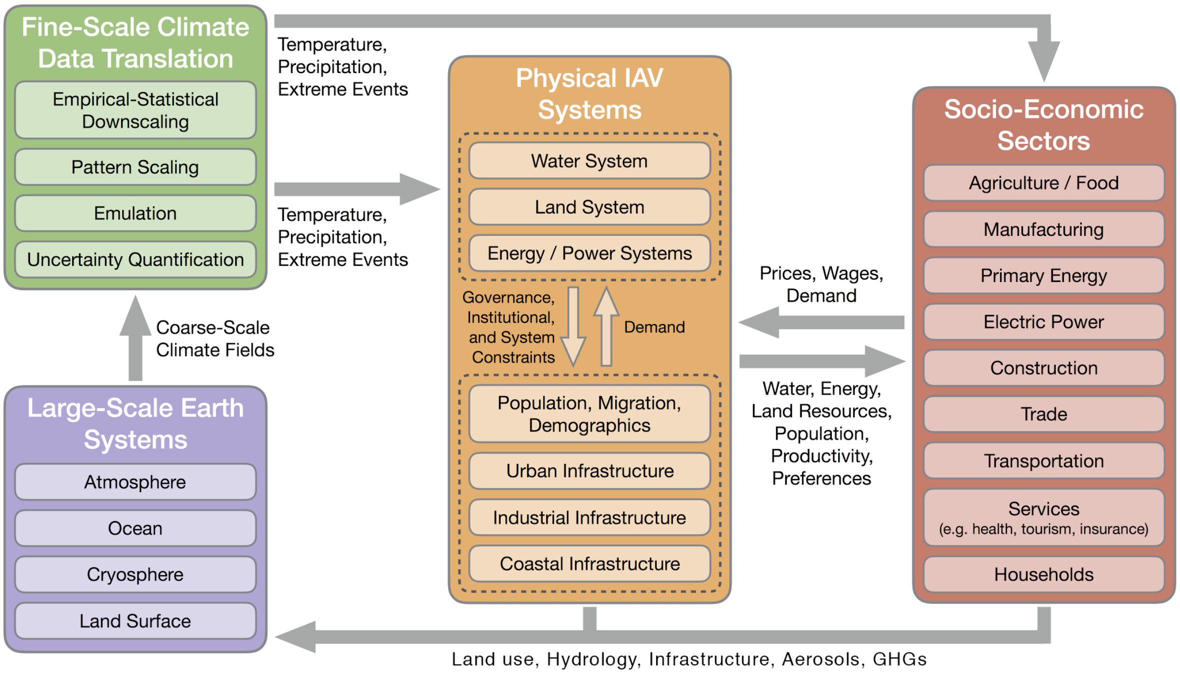
2. Governance, institutional, and system constraints are expected to play an important role in the evolution of regional economies under alternative climate futures, while relaxing these constraints and addressing market failures could alleviate some economic impacts. We are presently examining the use of fine-scale process models (water balance, power system) coupled with a detailed, multi-sector economic model of the Western United States, the latter acting as the coordinating mechanism between the fine-scale physical models and the function of markets under these constraints.

3. Earth system variability and change can result in a chain of cascading and adverse impacts on coupled land, energy, and water systems. We are examining various strategies for examining these cascades. Presently, we are pursuing the development of an econometric framework to assess these risks at global scales, where direct coupling of detailed process models is typically infeasible. This approach emphasizes the development of large scale statistical and process emulators that can be directly incorporated into a global MSD framework.

Beyond the systems interactions research encompassed within the three main focus areas, PCHES also supports advances in fundamental methodologies that crosscut and underpin these focus areas. This methodological research seeks answers to questions such as:

- How skillful are current empirical-statistical downscaling tools in their representation of decision-relevant information (e.g., modes and tails of relevant probability density functions or the spatio-temporal correlation structure) on regional to local scales?




- What are the inherent trade-offs between downscaling and emulation strategies (e.g., statistical emulators based on observational data versus mechanistic/process emulators based on model ensembles) for generating climate, weather patterns, and extreme event information for multisector dynamics?
- What are the driving mechanisms and projected magnitudes of future changes in the frequency, duration, and intensity of weather extremes, including intense rainfall events, heat waves, floods, and droughts? And how do these vary across spatial and temporal scales?
- What are new and innovative tools and methods for uncertainty characterization for integrated energy, land and water impacts assessments?

All of these efforts are coordinated across a diverse and geographically dispersed research team that intersects with many additional networks of informal collaborators around the globe.

Leadership, engagement, and coordination within this network of networks is a key program component spanning all PCHES research activities.

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