Modeling Interactions and Feedbacks across Energy, Water, Land, Urban, and Economic Systems to Explore Climate Vulnerability and Resilience in the USA

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Background/Objectives. The Integrated Multisector, Multiscale Modeling (IM3) foundational science research project, funded by the U.S. Department of Energy/Office of Science, focuses on developing flexible, open-source, integrated modeling capabilities that capture the structure, dynamic behavior, and emergent properties of the multiscale interactions within and between human and natural systems. IM3 uses these capabilities to study the evolution, vulnerability, and resilience of interacting human and natural systems and landscapes from local to continental scales within the U.S., including responses to the compounding effects of long-term influences and short-term shocks. A key objective is to understand the implications of uncertainty in data, observations, models, and model coupling approaches for projections of human-natural system dynamics.

Approach/Activities. IM3's first phase (2017-2020) focused on regional-scale energy-water dynamics, interactions between land use and land cover change and regional climate, and generating 1-km^2 population and urbanization projections consistent with the Shared Socioeconomic Pathways. Current research (2020-2023) is projecting the compound influences of climate change, heat waves, drought, and socioeconomics on the dynamic interactions between energy, water, land, and urban systems during the 21st century, while maintaining consistency with global socioeconomic conditions. Experimental objectives include understanding the key drivers and interactions affecting the evolution of urban heat stress, water scarcity, and electricity grid stress, including uncertainty characterization. Modeling scales include the continental U.S., major electricity interconnections, watersheds, and urban areas, and experiments investigate the fidelity implications of differential spatiotemporal and process resolutions across scales. IM3 is also coordinating (and invites participation in) an open Community of Practice to establish a conceptual framework for the field of multisector dynamics to accelerate progress across relevant projects and areas of research.

Results/Lessons Learned. This presentation will outline the scope and challenges of IM3 as a transdisciplinary project seeking to contribute new insights and modes of analysis across scales, sectors, and systems. We will present key insights obtained to date regarding the compounding influences of climate, heat waves, drought, and socioeconomic change on urban heat stress, water scarcity, and electricity grid stress.