GCIMS: EXPLORING DYNAMICS IN GLOBAL HUMAN-EARTH SYSTEM INFLUENCES, RESPONSES, AND FEEDBACKS

Interactions between human and natural systems are at the heart of many economic, environmental, and national security issues facing the United States and the world today.

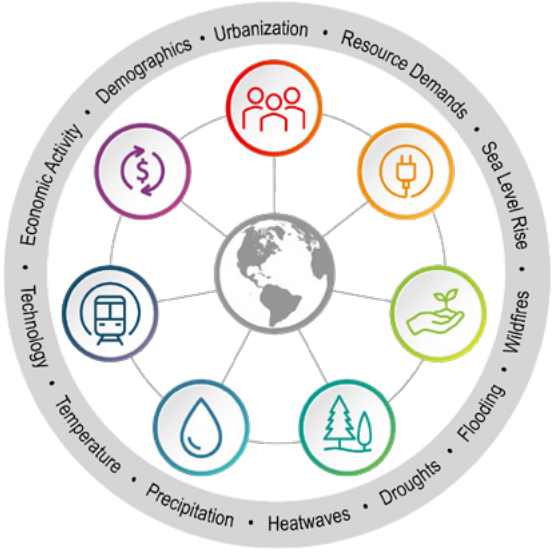
Because human and natural systems evolve in response to a wide range of short- and long-term influences, it is essential to understand and account for these complex dynamics. It requires innovative tools that represent the fundamental drivers of change and responses of individual systems. It also requires methods to characterize the multifaceted interactions and co-evolution of systems.

The Global Change Intersectoral Modeling System (GCIMS) scientific focus area aims to improve the understanding of the complex interactions among energy, water, land, climate, socioeconomics, and other important human and natural systems at regional to global and seasonal to centennial scales.

GCIMS is funded by the U.S. Department of Energy's (DOE) Office of Science as part of the MultiSector Dynamics program area within the Earth and Environmental System Modeling program. The emphasis is on developing and applying an internally consistent, open-source, and computationally efficient modeling framework that captures the integrated human-earth system's evolution.

GCIMS seeks to simultaneously resolve the effects of:

- Compounding short- and long-term influences on energy, water, land, climate, and socioeconomic systems over the next 10 to 100 years;
- The responses of these systems to those influences; and
- Previously unresolved feedbacks that fundamentally alter the frequency or intensity of influences.



In this figure, the outer ring highlights different human and environmental influences studied in GCIMS. The circles represent systems (e.g., energy, water, land, economy) affected by these systems.

SCIENCE QUESTIONS

The emphasis of GCIMS has evolved since its early days when it focused on a limited number of highly aggregated systems. Today, the team considers multiple interactions (energy-water-land-economy-climate) at greater temporal, spatial, and process resolution (regional-national-global and seasonal to centennial). The research team focuses on the following central science questions:

- How will compounding human and environmental influences affect the co-evolution of energy, water, land, climate, and socioeconomic systems? And what individual and combination of influences lead to compounding effects within the U.S. and across the globe?
- How will regional teleconnections via resource supply networks and trade create, amplify, or weaken the responses associated with different influences in the U.S. and other parts of the world? How will varying assumptions about the ease or difficulty of trade alter these teleconnections?
- How will human responses to short-term influences through investments in long-lived capacity and storage technologies in the energy, water, and land systems affect these systems' long-term dynamics? How will these investments affect the ability to respond to future influences?
- How could the response of the human-earth system to influences create feedbacks that are currently not captured in integrated modeling frameworks, and which feedbacks will result in substantial changes in the evolution of human and earth systems?

GCIMS SUPPORTS MODEL DEVELOPMENT

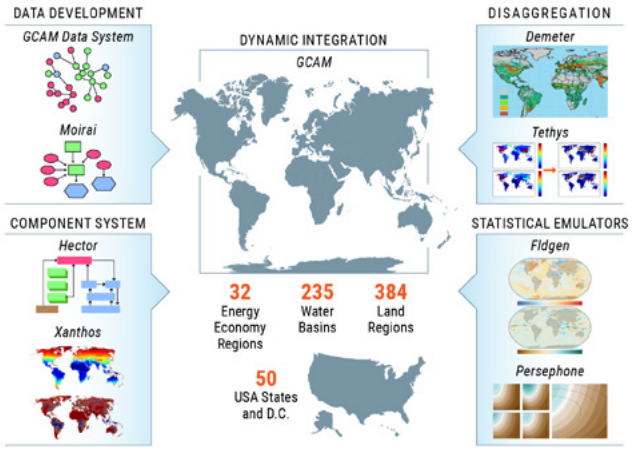
The GCIMS scientific focus area develops and uses the Global Change Analysis Model (GCAM), a leading human-earth systems model since its inception in 1981.

At its core, GCAM is an economic model with detailed physical system representations of energy, water, land, and climate components. GCAM is also used to represent the human component of DOE's Energy Exascale Earth System Model (E3SM).

GCIMS couples GCAM to a suite of open-source component models to represent physical systems (e.g., hydrology) or to translate GCAM outputs to a spatial scale. These component models include Hector (climate emulator), Xanthos (global hydrology), fldgen (climate variability emulator), Tethys (global water demand downscaling), and Demeter (global land use and land cover downscaling). The outputs from GCAM and GCIMS can be used in a variety of earth system and hydrologic models.

LOOKING AHEAD

GCIMS research is positioned to lead to scientific advances by improving the integrated understanding of influences, responses, and feedbacks in the coupled human-earth system. A key focus is understanding how human and earth systems interact with one another globally and regionally in response to short- and long-term influences, and the implications of these responses and feedbacks for the co-evolution of energy, water, land, socioeconomic, and climate systems.



Models and linkages within the Global Change Intersectoral Modeling System (GCIMS), which couples together a suite of open source component models including GCAM.

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