INTEGRATED COASTAL MODELING (ICOM): PREDICTIVE UNDERSTANDING OF COASTAL INTERACTIONS AND RISKS

Coastal regions are exposed to a wide range of natural hazards, such as hurricane-induced flooding, that are increasing in frequency and intensity. Meanwhile, the dramatic growth in coastal populations has increased the exposure of people and infrastructure to many of these hazards.

There are many activities underway to observe, understand, and project future changes in coastal systems, along with the corresponding risks. However, coastal processes are challenging to simulate in numerical models due to the presence of multiple interacting stressors and complex coupled interactions between human and natural systems across a wide range of spatial and temporal scales.

The U.S. Department of Energy's (DOE's) Integrated Coastal Modeling (ICoM) project is designed to develop, evaluate, and apply a range of modeling tools to systematically analyze coastal processes, hazards, and responses. The ICoM team is a multi-institutional partnership led by Pacific Northwest National Laboratory with broad expertise in modeling human and natural systems and evaluating coastal risks.

ICoM's mid-Atlantic study region.

CHALLENGES

Three central science questions are guiding the ICoM research team:

- How do interactions across different coastal systems and processes—including land-river-estuary-ocean fluxes, atmosphere-surface-subsurface interactions, and interplays between human activities and natural earth system components—influence coastal hazards?
- To what extent could long-term changes in coastal environments—including sea-level rise, human development patterns, geomorphology, vegetative dynamics, biogeochemistry, and deliberate or autonomous adaptations—alter the exposure, vulnerability, or resilience of coastal systems?
- How might tipping points and shocks, such as extreme weather, rapid technological or infrastructural changes, ecological shifts, and compound stressors, lead to significant impacts or major nonlinear changes in the coevolving human and natural systems in coastal regions?

GEOGRAPHIC FOCUS

The first three years of ICoM will focus on the mid-Atlantic region, which exhibits a wide diversity of coastal development patterns and is home to dense networks of connected infrastructure that is often stressed or disrupted by hurricanes, extratropical storms, droughts, and other extreme events. The tools developed under ICoM will be broadly applicable to other coastal regions.

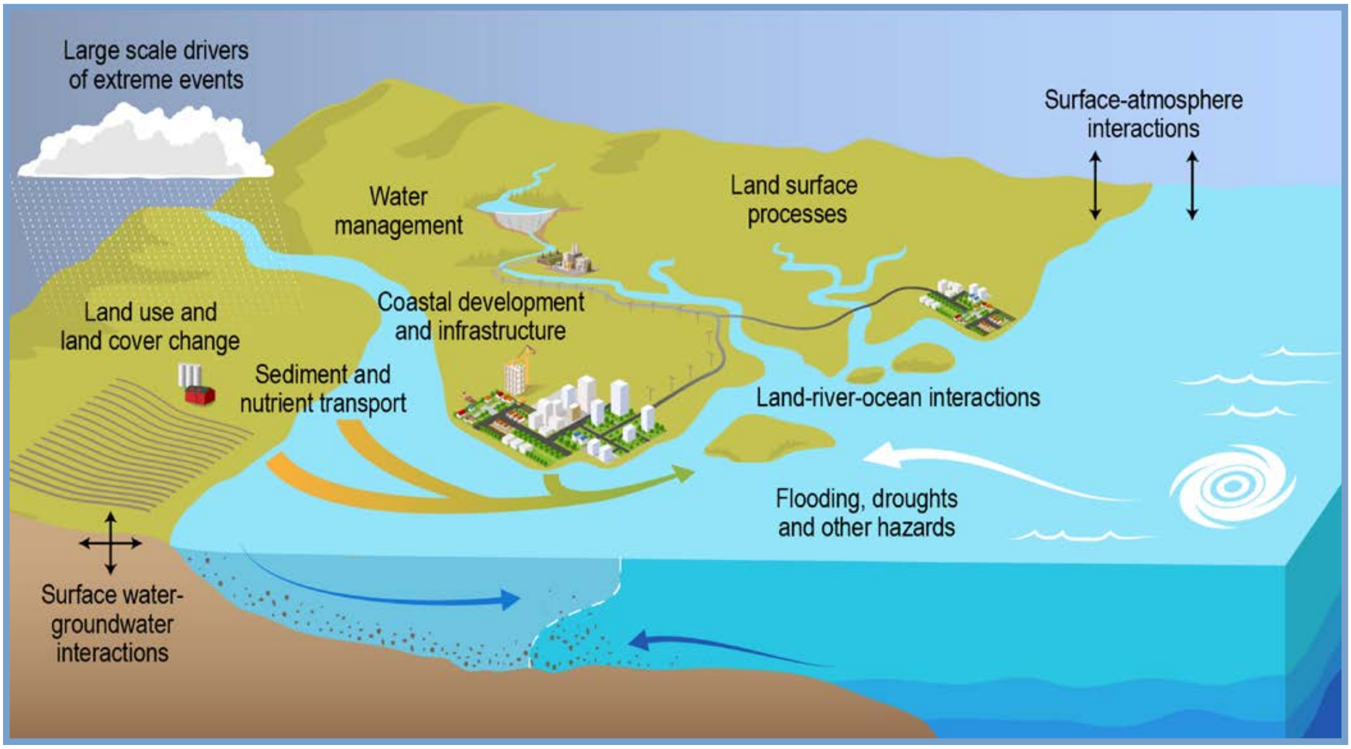
RESEARCH AREAS

ICoM is sponsored by four activities in DOE's Office of Science:

MultiSector Dynamics research focuses on coupling infrastructure, coastal development, and hazard modeling and emulation capabilities to characterize the time-evolving risk and resilience of co-evolving human and natural systems.

Regional and Global Modeling and Analysis research focuses on improving scientific understanding of how large-scale meteorological patterns and surface-atmosphere interactions drive mid-Atlantic extreme events.

Earth System Modeling Development research focuses on extending the Energy Exascale Earth System Model (E3SM) to better resolve human–land–river–ocean interactions, including cross-component transport of salinity, sediment, and nutrients.



Overview of ICoM Research Activities.

Subsurface Biogeochemistry research focuses on characterizing subsurface hydrological response and its interaction with surface water under sequences of extreme droughts and storms.

Cross-Cutting Research focuses on the role of coastal development patterns in driving natural system changes, including key biogeochemical and hydrological processes, and on evaluating the strengths and limitations associated with different coastal modeling techniques.

OUTCOMES AND FUTURE WORK

Collectively, these activities will represent a major step towards a long-term vision of delivering a robust predictive understanding of coastal evolution that accounts for the complex, multiscale interactions among physical, biological, and human systems. ICoM will also provide a cornerstone for a larger program of activities within the DOE's Office of Biological and Environmental Research (BER) that will transform our ability to observe, understand, and predict the evolution of coastal environments in the context of broader human and Earth system changes.

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