# The University Consortium for Geographic Information Science

# Research Priorities

## Dynamic Modeling

### The Priority

The objective of this research challenge is to extend the scope of traditional GIScience to Dynamic GIScience.

### Description of Research Challenge

This challenge explicitly recognizes the spatio-temporal nature of dynamic phenomena. 'Change' is the pervasive theme of our times. Understanding dynamic processes requires new methods and theories that overcome the limitations of current approaches. A few examples illustrate current shortcomings:

- Researchers in epidemiology are only beginning to have access to tools for modeling dynamic processes on richly structured landscapes.
- Current models of (sub-) urbanization processes focus on spatial effects but fail to capture the underlying processes such as cycles of neighborhood gentrification and decay, or cultural or economic agglomerations such as theater districts or high tech corridors.
- Dynamic transportation models cannot yet be embedded within their geographic environment. Applications would include social and economic impacts as well as emergency response situations such as 9/11.
- Present climate models are still crude, both in scale and conceptualization. We need better ways to represent process interactions across scales such as feedback effects between plant physiology and climate.
- Deforestation has been recognized as a major threat to humankind, yet existing research has difficulties defining and modeling land cover change.

We do not have to reinvent the wheel. Dynamic modeling incorporates a range of methodologies, many of which are borrowed from the GeoComputation community, that recognize the importance of combining space and time. Prominent among them are: (1) agent-based computational laboratories on richly structured spatial landscapes; (2) cellular automata and network extensions; (3) differential equation modeling; (4) diffusion modeling; (5) nonlinear models of relative dynamics; (6) spatial evolutionary algorithms; and (7) times series regression.

These methodologies include both data- and model-driven approaches

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and are founded on and extended by new theories such as 4-dimensional extensions of the part-whole debate.

## Importance of Research Challenge

The discipline of geography identified (discovered) processes as a crucial element of its research a good 100 years ago. Most (not all!) of GIScience, however, is treating its subject matter as if it were static. Lip service, where 'spatial' is replaced by 'spatio-temporal', does not change the fact that to date our community has not truly embraced the dynamic nature of the field. In order to fully capture this dynamism with GIScience, researchers must embark on a concerted research effort that goes far beyond putting time into GISystems and to incorporate current spatial dynamic modeling efforts within our community and beyond. Dynamic modeling under the GIScience umbrella covers all kinds of real world processes as well as their abstractions. It offers to expand the decision making power of current GIScience approaches by orders of magnitude.

## Eminent Research Questions

In order to address some of the above issues, we need to solve (and sometimes revisit) the following research challenges and questions:

- In spite of numerous attempts at developing spatio-temporal data models, we are still far an accepted standard. Is time a dimension or an attribute? Just one or many? Which temporal axioms are interchangeable with their spatial counterparts? What role does cognition play?

- Human-environment models require the ability to link continuous (differential equation) models with discrete agent-based models.

- Scaling – the attempt to integrate research at different temporal granularities. For example, matching research in coastal dynamics at the hydrodynamic scale of the individual wave with coastal evolution over thousands of years.

- The emergence of macro-scale phenomena as a result of micro scale interactions that in turn affect those micro scale phenomena. The resultant uncertainty of such typically nonlinear interactions among the spatio-temporal processes requires new theories and methodologies that recognize the complexity of the dynamic phenomena we model.

- We have come to develop the conceptual models of objects and events but neglected to acknowledge that their behavior is context-dependent. The development of domain object models and process libraries that are context-aware and can adapt to changing contexts poses a major intellectual challenge.

## References


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