UGEC-NASA workshop: Forecasting urban growth (FORE)

Pre-workshop comments: Keith C. Clarke (kclarke@geog.ucsb.edu)

1. What are the key urban remote sensing/urban modeling and forecasting issues that you represent?

I have been working in the area of urban growth and land use change modeling for about 20 years. I am the author of the SLEUTH urban growth/land use change model, which has over 100 applications on every continent except Antarctica. I was one of the three organizers of the GIS/EM 4 conference in 2000, which produced a book on integrating GIS and environmental modeling. As PI on the NSF funded UCIME project, I led a team that did integrated local scale modeling for the Santa Barbara region that became the basis for the regional general plan, the Regional Impacts of Growth Study. My personal role has been research aimed at: (1) "honesty" in modeling, in which sensitivity testing and model error become integrated components of a modeling system; (2) improving model performance with geocomputation, grid computing and high performance parallel computing methods; (3) investigating how modeling outputs can be used in human decision making, such as charrettes and scenario-based planning. I have followed the literature closely for cellular models, agent-based models, and for model integration. I also work in remote sensing and mapping, and have done extensive work in urban segmentation, land use intensity and 3D modeling.

2. What are the key challenges, missing opportunities, and exciting developments in your theme and region?

Challenges can be summarized as: (1) data fusion, especially ensuring semantic and geometric continuity over time; (2) geocomputation, the use of advanced computing methods to enhance modeling and to allow solutions to problems with high computational complexity; (3) visualization, the integration of cartographic and visual analytics outputs within systems that support meaningful visual analysis and group decision making. Missed opportunities are: (1) lack of coordinated LU mapping efforts that are centralized and standardized, and that remain consistent over time e.g. Europe's MOLAND program; (2) the lack of a multi-purpose modeling language or common operating environment that supports model integration, such as that originally envisioned for SWARM; (3) lack of academic or policy based leadership, responses are ad-hoc and program specific (e.g. Biofuels); (4) the closed nature of central government funded LU modeling efforts, and the lack of cross-discipline model development and application programs. Most exciting developments are low cost and high capacity computing, high resolution overhead remote sensing, sensor networks, and the richness of open source programming and scripting environments.

3. Why are we not seeing more studies on smaller urban areas?

I am seeing quite a few applications in smaller urban areas. What is lacking is work that crosses urban regions or compares urbanization across nations/continents/economic systems. Few models apply well to scattered or sprawled regions. There has been a focus on China due to growing PRC interest in modeling, and the need to study where the growth issues are most concentrated. Few models also scale well.

4. What platform/data/access limitations do you currently/frequently encounter?

High resolution imagery is expensive and privately sold. Few scientists can do satellite tasking, so data streams are irregular and the "scene" model often prevents meaningful fusion. Integrating map and digital cartographic data with sensor information is a challenge. The low classification accuracy of satellite-derived coarse and mid-level resolution imagery is a problem. Acquiring data in sensitive areas can be a problem. Also, few models can predict how cities change internally (i.e. Repurpose) or decline in the short or long term.

5. How do these limitations affect our ability to monitor, model and forecast urban areas?

The net result is that models are restricted in the reach of their forecasts, in the measurement and reliability of

uncertainties, in their accuracy and precision, and in effective use in public policy making and decisions. Models cannot as yet link cartometric and socio-economic themes, nor can they accurately assess impacts on water, soil, atmosphere, etc. We cannot gather sufficient data to map all cities of all sizes and in all places. Neither can we do large scale modeling of complete systems. Resolution and access is too low, temporal sampling is too infrequent, data richness in terms of features and their classification is too restrictive, and fusion error often exceeds modeling error, yet the consequences for decisions based on models are unknown when “best available data” are used. There are no theoretical models to relate urban growth and land use change as processes to what is known about other processes, such as diffusion and erosion.

6. What do you see as missing in terms of case studies and methods?

I'd like to see more modeling at the 1m level, and for entire systems (e.g. All 48 lower United States at once). Models applications relevant to hazards are lacking (e.g. New Orleans). Models should be compared more, and more rigorously tested. Standard methods should be used to quantify and report a models explanatory power and success. Rather than missing case studies, I think we are missing simple applications that can be used in education and training. There should also be “model” or classic data sets, so that models can be tested and compared under identical circumstances. In terms of methods, it would be nice to have better methods to display and explored change, both visually and quantitatively. Lastly, rather than more case studies and applications, I'd like to see more meta-analyses and massive scale applications.