

## Responses to the Six Questions – Burak Güneralp

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

The prediction of urban patterns remains challenging. This is due to interactions of many factors that have a bearing on where development to occur. More critical, in my view, is that some of these factors may involve a certain level of randomness akin to quantum mechanics and may never be possible to predict accurately. Certain research questions such as interactions between region-level processes and neighborhood-level processes call for adequate representation of dynamics that span multiple levels. Such multiscale representations in land change models remain challenging especially considering land change models do only moderately well even at a single scale.

Process-based representation of land change dynamics is essential for deeper understanding of land change phenomena in any one place. Urban metabolism, on the other hand, is an approach to identify the specific types of material flows through an urban system to meet residential and consumer demand and support commercial and economic activities. I am interested in integration of urban metabolism approach with spatially-explicit land change models to track indirect impacts as well as direct environmental impacts and how they change over time with changes in demographic and economic composition, and intuit about their future patterns. Such an approach calls for quantification/estimation of these impacts using remotely sensed imagery in addition to data on material use including water and energy demand.

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

A key challenge is getting the patterns right. It has always been a challenge to accurately predict the spatial patterns let alone their change over time. The configuration of different land uses across the landscape is a critical component in biogeochemical cycling, regional climate, and energy demand for transportation. We need to start doing a better job in predicting patterns accurately.

A critical missing opportunity is the lack of sharing of the extensive knowledge base on land change and its modeling across the world. Notwithstanding the unknowns, there is a large body of information/knowledge collected by academicians/practitioners over decades. This knowledge, however, is fragmented and thus remains diffused across research groups all around the world. A closer network of researchers (including, but not limited to, remote-sensing community and urban modelers) would facilitate better coordination and eliminate effort-duplication.

An exciting development is the increased recognition of the integrated nature of many social and biophysical processes. In the context of urban land dynamics, this means that there is much more emphasis on the influence of patterns of urban land change –in addition to, for instance, demographic factors–on resources demand and even urban ecosystem functioning. The increased effort to better understand the underlying factors in observed urban patterns (not only over time but also across space) can have a meaningful positive impact on relevant policy considerations.

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

While the smaller urban areas are collectively where most urbanization will occur for the next couple of decades, individually, they do not draw as much attention as the largest urban agglomerations such as Los Angeles or Shanghai metro areas. In fact, there is not much awareness of their collective importance

either within the larger academic world or among public. Regional or global initiatives aimed at comparing and contrasting smaller urban areas from different countries and regions of the world may go a long way towards drawing attention to such places and a research program based on that initiative may have the intellectual appeal to attract researchers.

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

Locating and quantifying land use impacts elsewhere due to material demands in urban areas (either from building construction and operation or from consumer demand) is extremely problematic. However, the most critical limitation is probably the availability of reliable data from places where most urbanization will occur in the future. For many places in the developing world, socio-economic data specifically on urban areas in developing countries either do not exist or are not of high-quality. In addition, while the remote-sensing data ease most of the issues related to land use land cover data, one still needs field data for accuracy assessment. Collecting field data is either costly or challenging in many urban areas around the world. This may be particularly challenging in places with poor transportation infrastructure or affected by conflict.

Quantifying the impacts of urban expansion requires spatial data that is of sufficient resolution to allow for gaining information on types of building materials road networks etc. This is also the case when it is the urban patterns that are of primary interest. Landsat data, although freely available from USGS for many places around the world, is not of sufficient spectral or spatial resolution for these purposes. On the other hand, Quickbird and Ikonos data with resolution as fine as 1m are prohibitively expensive. Third (vertical) dimension can be obtained from radar remote sensing but again it is generally not affordable and not widely available. Moreover, data from these sensors –once available– may require long times to process for large areas.

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

One consequence is disproportionate representation of urban areas from around the world meaning that there is a lot more research on developed-country cities than on developing-country cities. This is an issue because most urbanization will take place in developing countries. Another is the lack of a well-developed knowledge base to prepare urban areas for adaptation and mitigation in the face of climate and socioeconomic changes. This is again most critical in the case of developing country cities because they need to make the most efficient use of their scarce resources for adaptation and mitigation. In the face of data limitations, researchers have to make assumptions regarding the vertical structure of urban areas, the composition of buildings, and spatial patterns of urban areas all of which add layers of uncertainty to findings from studies that rely on such information.

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

I would like to see more emphasis on urban-rural connections as well as more comparative studies across urban areas from different geographies. This would involve explicit attention being paid to indirect impacts of urbanization. Urban modeling should be more process-based including significant social and economic factors. I also would like to see uncertainty that we know is present in the data and the methods to be more explicitly and methodically taken into consideration in modeling studies. If we know that uncertainty exists in real world we should not pretend otherwise in our modeling studies.