meeting/workshop summaries

Spring 2012 NASA Land-Cover Land-Use Change Science Team Meeting

LeeAnn King, University of Maryland, College Park, mkinglee@umd.edu
Chris Justice, University of Maryland, College Park, justice@hermes.geog.umd.edu
Garik Gutman, NASA Headquarters, garik.gutman@nasa.gov

The NASA Land-Cover Land-Use Change (LCLUC) program hosted its annual spring science team meeting, held April 3-5, 2012, in Rockville, MD. This year's meeting focused on *urban land dynamics*. More than 100 scientists and graduate students from the LCLUC community attended the meeting, which, in addition to offering presentations on urban land use, included a review of the final results from the project's third year of activities, posters and discussion sessions on improving the social science component of LCLUC, and the role of collaborative synthesis research. Representing international partners at the meeting were **Giovana Espindola** [Global Land Project (GLP)—*Executive Officer*], **Lei Wang** [Chinese Academy of Sciences, Institute of Remote Sensing], and **Oganes Targulyan** [ScanEx[1]—Russia]. Representing regional partnerships were **Pavel Groisman** [Northern Eurasian Earth Science Partnership Initiative (NEESPI)—*Project Scientist*] and **Hassan Virji** [Global Change SysTem for Analysis Research and Training (START)—*Director*].

Spring LCLUC Science Team meeting participants take a break to pose for a photo.

Garik Gutman [NASA Headquarters—*LCLUC Program Manager*] and **Chris Justice** [University of Maryland, College Park—*LCLUC Program Scientist*] cochaired the two-and-a-half-day meeting. **Gutman** began the meeting with a brief review of the program, including a description of the current suite of recently funded projects. He explained that the urban component of the LCLUC program is aligned with the International Human Dimensions Program (IHDP) Urbanization and Global Environmental Change (UGEC) Project, which promotes assessments of urban land-use-change effects on global environmental change, including the impacts of built-up environments on energy use, carbon emissions, air quality, and climate. The urban-change component of the LCLUC program is also responsive to the deliberations of the Intergovernmental Panel on Climate Change (IPCC). The IPCC's Fourth Assessment Report (AR4) focused on the effects of anthropogenic greenhouse gases; the next IPCC report (AR5) will put more emphasis on the role of urban land use in climate systems.

Gutman also emphasized implementing NASA's priority of free and open sharing of data, and described the recently introduced opportunity for LCLUC scientists to use the NASA Earth Exchange (NEX) portal that provides access to state-of-the-art supercomputing for Earth system modeling. He reiterated the LCLUC program's expectation that principal investigators (PIs) of funded projects make both their results and associated datasets available to the broader community in a timely fashion. Gutman highlighted an emerging international initiative to develop cooperation between the Landsat program and the European Space Agency's (ESA's) Sentinel-2 program on merged data processing and products, with an initial focus on more-frequent observations for agricultural land use. He also described the program's continuous efforts to involve early-career scientists through the current Research Opportunities in Space and Earth Science (ROSES) solicitation or as an integral part of each international LCLUC science team meeting. Gutman also mentioned a new Trans-Atlantic Training Initiative led by NASA and ESA. He finished by describing the 2012 funding solicitation, which includes two elements: mapping industrial forests from Landsat-class observations, and synthesis of LCLUC studies in Eurasia. *Synthesis studies* involve advancing the conceptual underpinnings of LCLUC science with state-of-the-art knowledge; increasing our understanding of processes, drivers, and impacts of LCLUC; and developing new understanding and conceptual frameworks. Gutman explained that the LCLUC program recognizes the need to include aspects of social science when studying land use, and

[1] ScanEx is the leading Russian company for remote sensing applications.

that the program evaluates a proposal's social science responsiveness in terms of a meaningful integration of social-science theories, methods, and quantitative or qualitative data in all proposed research.

Chris Justice outlined the current science direction for the program, and identified new study areas in land-use and sustainability research. Such study areas include land-use vulnerability to climate change (particularly in marginal areas), and creation of a new generation of satellite-derived land-use products for parameterizing the new class of integrated assessment models. He emphasized that with NASA's increased access to fine-resolution data, there is a need for automated methods for fine-resolution classification and for change detection. Justice highlighted the adaptation science element of the U.S. Global Change Research Program (USGCRP)'s Strategic Plan, the emerging international Future Earth Research for Sustainability initiative, and the current National Research Council (NRC) Study on Land-Use Modeling. He concluded with some thoughts on LCLUC research, using data from new and upcoming NASA missions. Further information on the LCLUC program can be found at *lcluc.hq.nasa.gov*.

The agenda provided time to discuss the roles of synthesis initiatives in LCLUC research. **Karen Seto** [Yale University] chaired the session, beginning the conversation by identifying the USGCRP Strategic Plan as a guide for integrating *social science research*, and emphasizing the importance of finding experts to evaluate the "human component" of LCLUC research proposals. Discussion followed on defining social science research in terms of LCLUC, the role of anthropogenic drivers on land-use change, and the importance of identifying indicators of sustainability and understanding the anthropogenic aspects of LCLUC. Seto acknowledged that synthesis studies can vary widely in the their scope, as reinforced by the next two presentations.

The discussion continued with presentations by two PIs currently funded for synthesis studies. **Kathleen Bergen** [University of Michigan] emphasized the importance of clearly articulating the goals and methods of the synthesis project and the difficulties her study encounters when integrating across different scales and topics. **Volker Radeloff** [University of Wisconsin, Madison (UWM)] stressed the importance of government policies on LCLUC for his synthesis project, and how they influence land-use change in different countries; there is also a need to frame the synthesis so that research objectives are manageable. He suggested that international collaboration can strengthen synthesis, and that existing in-country projects can provide an indication to international researchers of what may be possible. During the discussion, participants concluded that, with the growing number of local research studies on LCLUC funded by different agencies around the world, there is a real need—and opportunity—for synthesis, but that a compelling case needs to be made for each synthesis study, with a clear statement of rationale and a conceptual framework for the study.

Earth's population is becoming increasingly urban, with projections that 70% of the world's population will be living in urban areas by 2050. Commonly, the growth comes from areal expansion of urban areas rather than density increases, with the *built environment*—land used for urban development—often occurring at the expense of productive agricultural land. Such urban sprawl changes the land surface—altering surface fluxes of heat, water, and carbon—which in turn impact the water, carbon, and energy cycles, changes weather patterns, and ultimately alters climate. While clear on the grand scale, the details describing actual rates of urban expansion and increased density and the corresponding impacts these changes have on biophysical properties in the environment remain largely unknown. NASA is currently supporting several projects that explore this urbanization phenomenon in the context of land-cover and land-use change; several of the PIs presented relevant research progress and preliminary results at the meeting.

Eric Brown de Colstoun [NASA's Goddard Space Flight Center (GSFC)] opened the *Science of Urban Land-Use Change Session* with an overview of his project, titled *Using Landsat Global Land Survey (GLS) Data to Measure and Monitor Worldwide Urbanization*. The project uses the Landsat surface-reflectance dataset to develop a baseline global estimate of the percentage of *impervious surface* (*i.e.* urban) cover for 2000 and 2010. These data are then used to detect and map urbanization "hot spots." Field measurements of urban areas will be gathered as part of a youth education and outreach program, through which the project will train primary and secondary school children to collect impervious surface presence data near their schools. This is a component of the GLOBE Program, a worldwide project engaging children in hands-on science[2].

Marc Imhoff [GSFC] provided a summary of his recent publication in *Remote Sensing of the Environment* [3]. There are numerous consequences of urbanization, including the loss of fertile soils, changes in net primary production (NPP) potential, and increases in local temperature. The study investigated the correlation between land surface temperature (LST), impervious surface area (ISA), the normalized difference vegetation index (NDVI), and their varying relationships within U.S. biomes. The conclusion is that there is considerable variability in the impact of change as a function of biome, and that the *legacy of fluxes* determines the intensity of the degree of the observed

[2] Visit *globe.gov* to learn more about GLOBE.

[3] Imhoff, M.L., P. Zhang, R.E. Wolfe, and L. Bounoua, 2010: Remote Sensing of the Urban Heat Island Effect Across Biomes in the Continental USA. *Remote Sensing of Environment*, **114**: 504-513, doi:10.1016/j.rse.2009.10.008.

Robert Wolfe [GSFC] and **Yuri Knyazikhin** [Boston University] converse during the poster session.

change: Variations in ISA explain 88% of the variation in LST for urban areas in forested biomes, whereas in desert environments the LST's response to ISA presents a "U-shaped" horizontal gradient, decreasing from the urban core to the outskirts of the city, and then increasing again in the suburban-to-rural zones. The study also found that there is a decrease in LST for cities in deserts during summer days—potentially caused by increased shading in these areas. The next step for the project will be to use a combination of satellite and ecological map data to extend the characterization of the urban heat island response to global urban settlements. Imhoff proposed that the urban heat island effect may result in phenological change to the biome, which involves longer growing degree days for vegetation in these areas. He also mentioned the importance of local influences, explaining that the concept of ISA as applied in the U.S. may not transfer to developing country cities where urban infrastructure characteristics and environmental properties are often different.

Peilei Fan [Michigan State University] described her LCLUC project, titled *China's Urbanization and Its Sustainability Under Future Climate Change*, which investigated causal linkages between urbanization, urban sprawl, and climate change. The project simulated LCLUC and local-scale IPCC-generated climate scenarios, considering different urbanization circumstances for a variety of future climate change predictions, and provided adaptation recommendations on various LCLUC and future climate scenarios for Shanghai and Urumqi, two major cities in China. Fan used the Conversion of Land Use and its Effects at Small regional extent (CLUE-S) model, with historical data describing LCLUC over the past 50–60 years to forecast potential urbanization and land-cover conversion dynamics for each city under different growth scenarios. The project also modeled climate change scenarios using the Regional Atmospheric Modeling System (RAMS) to investigate the impact of potential changes in land cover on atmospheric dynamics overall, to test whether recent trends in land-cover change will act to suppress rainfall, and to examine how urban expansion will affect these variables from the present through 2050. Fan also used modeled urbanization and climate scenarios to forecast a change in intensity of the thermal environment at the urban core and the spread of heat island effects to the city's periphery. Further model development is currently being conducted, and will continue this year.

Annemarie Schneider [UWM] is leading an LCLUC-funded project that focuses on urban systems in China, and seeks to monitor and model urbanization using mixed methods and a multiscale approach. Schneider described the difficulties associated with the use of moderate-resolution remote-sensing data for urban analysis—difficulties that arise because of the fine spatial and temporal scales of changes that occur at the city level. She also described a number of different drivers that have led to drastic land-cover change in China over the past 30 years. The 1978 economic land reforms resulted in *decentralization*, a change in land-use rights, liberalization of the household registration system (*hukou*) and the work unit (*danwei*), and provided a gateway for the great western development program of the 1990s and early 2000s. These reforms resulted in rapid rural-urban migration and land-use change, agricultural expansion and intensification, and a rise in both gross domestic product (GDP) and incomes in China. Schneider explained that the variation in the rate of change in an area can stem from multiscale planning, preferential policy or development zones, foreign direct investment, fiscal transfers, road development, economic transition, and migration. Moderate-resolution data can be used for supervised multitemporal classification of urban growth, although independently measuring each variable's relationship to change is more difficult. Schneider recommended keeping the analy-

sis simple by isolating independent variables to identify their influence on the phenomenon.

Karen Seto described her LCLUC-supported research in India, currently conducted as an international collaborative effort using multiscale and multisensor analysis of urban cluster development and its relationship to agricultural land loss. Substantial urbanization throughout India can be attributed to nonlocal actors and global markets, and can be identified and monitored using a combination of data from the Moderate Resolution Imaging Spectroradiometer (MODIS), a Night Time Lights indicator, Landsat Thematic Mapper/Enhanced Thematic Mapper, and Système Pour l'Observation de la Terre-Vegetation (SPOT-VGT) data. These satellites' observations are complemented by local demographic statistics and discussion from meeting with public and private policy shapers to describe current urban clustering throughout the region. Preliminary results show that it is possible to monitor urbanization using these datasets; therefore, database development, algorithm refinement, model building, and fieldwork are planned for next year to further the analysis of urban growth and agricultural land loss in and between cities in India.

Cristina Milesi [NASA's Ames Research Center] showed how her project, titled *Mapping of Urban Expansion Using Multi-Decadal Landsat and Nightlights Data over North America*, will characterize urban expansion using Landsat and Quickbird data from 1990 to the present. She is using a robust linear spectral mixture model to distinguish between heterogeneous urban areas across different geographic, environmental, and socio-economic regions, to identify rapid land-cover changes, and to characterize the land covers that are being replaced. The dark fraction of spectral reflectance can be used to identify impervious fraction by masking water and high-albedo regions, rural areas, and agricultural lands near urban areas. Preliminary results from the Spectral Mixture Analysis display very strong similarities with National Landcover Database (NLCD) 2006, though overall values are higher than the NLCD 2006 urban land cover. The preliminary results show that the largest urban growth can be found at the periphery, with some intensification of pixels previously characterized as urban. The next steps for the project involve refining end-member selection for atmospherically corrected global Landsat mixing space, vicariously validating[4] impervious fractions with multispectral high- resolution Web-based Access and Retrieval Portal (WARP) datasets, and extending the multitemporal analysis to North America for 1991, 2000, and 2010.

After a vibrant discussion and several informative presentations on project progress and results, several issues needed further debate. A survey will be circulated throughout the LCLUC community, requesting input from the meeting participants and project investigators to help address synthesis research, the social science component of LCLUC research, and the program's direction. **Garik Gutman** closed the meeting, expressing the importance of the annual science team meeting as a forum for sharing results, enabling discussion and feedback to the program, and for initiating collaboration and building teams. He also emphasized the importance of enhancing linkages with international programs, such as the Global Observations for Forest and Land Cover Dynamics (GOFC–GOLD) and Group on Earth Observations (GEO), and regional programs like NEESPI and Monsoon Asia Integrated Regional Study (MAIRS), in which regional networks, supported by START, play a critical role. Gutman concluded by stating that each science team meeting has a specific focus, and that important aspects of the meetings would be enhanced by inviting international partners and early-career scientists. The presentations, posters, and other details from the meeting can be downloaded from *lcluc.umd.edu/meetings.php?mid=37*. ■

[4] In this context *vicarious validation* means the measurements will be compared with another well-known and very stable dataset—i.e., WARP.