

NASA LCLUC Spring Science Team Meeting Summary

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Land-cover/land-use change (LCLUC) remains the most visible manifestation of global change around the world. It is the subject of an integrated research program using NASA's assets to address the intersection between the physical and human dimensions of global change. The LCLUC Spring Science Team Meeting was held at the Bethesda, MD Marriott from March 31-April 2, 2009, with 89 participants, 27 presentations, and 27 posters. The purpose of this meeting was to hear results from funded research projects on the various impacts of land-use change and to update the community on related program developments. In addition, a special session was held to discuss the future directions for the human dimension of the program. A full day session was given for presentations and discussion of observations and data for LCLUC research.

Opening Session

The opening session included a program update from **Garik Gutman** [NASA Headquarters (HQ)—*LCLUC Program Manager*] who described recent proposal selections and a new Principal Investigator (PI) database to help with program reporting. This was followed by a presentation from **Mike Freilich** [NASA HQ—*Earth Science Division Director*] on how land-cover/land-use change science plays in to NASA's Earth Science Program. Freilich mentioned the FY09 budget and the stimulus augmentation; the need to complete the five Earth science missions now under development, including NPOESS Preparatory Project (NPP) and Landsat Data Continuity mission (LDCM); and the sequence of the Decadal Survey Missions. **The take-home message from the latter presentation focused on outreach, namely that the science community needs to communicate what we are doing and why it's important, achieve technical and substantive success in our activities, and articulate what we have discovered**

or demonstrated and its implications. The recent LCLUC brochure (lcluc.umd.edu/Program_Information/brochure.asp) is a step in this direction.

Science Presentations

The science presentations at the meeting took the form of a review, each with contributions from several program PIs, in

the context of the broader research sub-discipline in question. These review presentations can be downloaded from: <ftp://ftp.iluci.org/LCLUC/APR2009/>. A sample of the reviews is provided below.

In a review

of LCLUC impacts on regional hydrology in Central Asia, **Geoff Henebry** [South Dakota State University (SDSU)] pointed to three significant aspects of land change within this region, namely the continued land and water degradation resulting from irrigated cultivation in the Aral Sea Basin, the deintensification of agriculture in the semi-arid zone of northern Kazakhstan, and the collapse of livestock production within the region. These land-use changes have been driven by policies and institutions. Agricultural land-use practices have had a big impact on regional hydrology during the past two decades, modulating the magnitude, timing, and location of fluxes and stocks. He noted that regional climate models are being used effectively to study LCLUC impacts but that the *in-situ* hydrological monitoring networks needed to parameterize and validate the models have deteriorated since the 1990s. Recent research shows that observed trends in streamflow in the region appear to represent a climate signal and that precipitation trends may be a result of land-use and climate change.

Lahouari Bounoua [NASA Goddard Space Flight Center (GSFC)] presented a review of research on the biophysics, hydrology, and large scale urbanization in



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semi-arid regions. Bounoua showed that urbanization is increasing in semi-arid regions often at the expense of fertile agricultural land and that the resulting surface energy budgets are modulated mainly by albedo and transpiration. The urban heat island effect is not as marked as in temperate climates and the hydrological cycle is characterized by increased runoff during precipitation events. An inverse modeling technique was presented for assessing the minimum water requirements for irrigation systems in semi-arid environments. Water requirements for drip irrigation were shown to be about 43% of that needed for spray irrigation.

Chris Small [Columbia University] presented a review addressing the hydrological impacts of LCLUC on urban environments. Small reported on a number of modeling studies within the program, showing that although urban areas cover a small percentage (~3%) of land area globally, they have a disproportionate impact on the environment. Unprecedented urban growth has characterized the last decades of the twentieth century particularly in the developing world. Population density is a primary driver for nitrogen, phosphorus, and total suspended solid fluxes into our estuaries. Regional scale studies are showing the impact of urbanization on climatology and freshwater species richness. Modeling the impacts of future projections of urban land-use change reveals significant impacts on reduced base flow, and increased runoff and convective precipitation.

Volker Radeloff [University of Wisconsin] gave a review of LCLUC in Eastern Europe, which provides a “natural experiment” to address how broad-scale drivers and disturbance influence land use and study the impacts of diverged nations, socioeconomic upheaval, and land abandonment. Studies have quantified post-Soviet land abandonment, forest loss, and illegal logging. For example, using satellite data to locate and quantify afforestation and deforestation, carbon stocks are being tracked, showing that Georgia and Romania will remain carbon sinks for the foreseeable future. Satellite data are also being used to study the *rewilding* of lands. Radeloff showed some examples of the resulting negative and positive impacts on saiga and bear populations, respectively. Different policies provide stark differences in land use and land cover and resulting environmental and social issues for the nations of Eastern Europe.

The LCLUC program has supported a number of studies in the Amazon Basin, as part of the NASA Large-scale Biosphere Atmosphere (LBA) Experiment. **Eric Davidson** [Woods Hole Research Center—*LBA-ECO Project Scientist*] gave an overview of the LCLUC research in the LBA. Results using microwave data to map wetlands provided input for a basin-wide (i.e., below 500 m) estimate of methane emissions of 22 Tg C/yr. A combination of ground plots and microwave data were used to estimate total forest biomass for the basin (86

Pg C +/- 20%). The Amazon has experienced extensive land-use change over the last few decades. The rate of deforestation, the interannual variability, and the fate of deforested land have been successfully quantified using Landsat data. From 2001–2004, 20% of the deforestation was due to direct conversion to cropland. The Brazilian Space Agency estimated 12,000 km² of deforestation and 15,000 km² of forest degradation had occurred in 2007. During the 1998 El Niño event, the area burned was thirteen times more than the area burned in a normal year and was twice the area of deforestation. In the Araguaia Basin, river discharge has increased by 25% since the 1970s with two-thirds of that increase attributed to land-cover change.

Bob Walker [Michigan State University] summarized seven land-use modeling studies including simulation, econometric, agent-based, and behavior models. Models of deforestation have been generated at multiple scales with process-based projection capability, either projecting deforestation patterns associated with a given road network or generating road networks and providing scenarios of deforestation and forest fragmentation. Walker discussed a number of challenges to the modeling community including the goodness of fit, the treatment of model uncertainty, and capturing forest dynamics with different transitions.

Billie Lee Turner II [Arizona State University] gave a presentation on strengthening the human dimension of LCLUC. Areas for continued or future emphasis within the program include inferring and scaling human behavior; examining the tradeoff between land systems; inclusion of dynamic land-use change in integrated models as well as topical research areas of land-use and climate change, urbanization, the role of institutions in land-use decisions and the impacts of the changing global economy (macro structure); and role of international conventions on land-use change. There was considerable discussion following the presentation on the possible reasons for a recent decline in the social science component of the program and ways in which this component could be reinvigorated, including suggestions concerning future calls for proposals and the peer review process.

Observations and Data Session

The LCLUC observations and data session started with a sequence of presentations on the international observation programs in which the program is an active player. **John Townshend** [University of Maryland—*Chairman of the Integrated Global Observations of Land (IGOL) Theme*] presented an overview of the land Essential Climate Variables (ECVs.) The ECVs were developed by the Global Climate Observing System (GCOS) to meet the needs of the Framework Convention on Climate Change (UNFCCC) and include Land

Cover, Albedo, Fire Disturbance, Biomass, and Leaf-Area Index. Townshend summarized the ECV standards status document, presented to the Subsidiary Body for Scientific and Technical Advice (SBSTA) in 2007 and the Guidelines for Satellite Datasets and Products document developed by GCOS in 2009. He recommended the setting up of an interagency mechanism(s) to ensure that high quality ECVs are generated and that agency roles and responsibilities are clearly identified.

Jim Tucker [GSFC—*Co-chair U.S. Global Change Research Program (GCRP)/Climate Change Science Program (CCSP) Observations Working Group*] gave the U.S. GCRP/CCSP perspective on land observations, emphasizing the need for the continued combination of Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat sensors for the study of climate change and the carbon cycle. New capabilities of these sensors are needed for the study of vegetation height/structure and atmospheric carbon dioxide.

Tony Janetos [Pacific Northwest National Laboratory—*Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) Chairman*] gave an overview of the activities of the GOFC-GOLD Program, which is a major international program on land satellite observations. He emphasized the on-going Reducing Emissions from Deforestation and Degradation (REDD) Sourcebook initiative, a new implementation team being formed on biomass monitoring and change, and a new initiative on land use being undertaken jointly with the Group on Earth Observations (GEO) focusing on global agricultural monitoring.

Joanne Nightingale [GSFC] presented on recent developments of the Committee on Earth Observation Satellites (CEOS) Land Product Validation (LPV) Working Group and the teams and validation protocols and reporting standards being developed for land-cover change, fire, biophysical characteristics, surface energy, land-surface temperature and soil moisture.

Martha Maiden [NASA HQ—*Chair CEOS Working Group on Information Systems and Service (WGISS)*] gave an overview of WGISS activities and their relationship to the Group on Earth Observations (GEO), with emphasis on the Land Surface Imaging Constellation, the Data Democracy initiative, and the Disaster Societal Benefit Area (SBA). She also discussed cooperation with the CEOS Working Group on Calibration and Validation (WGCV) on global datasets and quality.

The second session on observations focused on Landsat. **Jeff Masek** [GSFC] presented the status of the Global Land Survey (GLS)—a joint NASA/U.S. Geological Survey (USGS) project—to provide global orthorectified datasets for 2005 and 2010. The sets contribute to the GEO Task on Global Land Cover (DA 0903a).

GLS 2005 is now complete and letters have been sent to solicit international participation in GLS 2010.

Jim Irons [GSFC] presented the status of LDCM. This mission has been nine years in formulation. The Critical Design Review for the Operational Land Imager (OLI, a.k.a., Landsat 8) was completed in October 2008. The retargeted launch date is December 2012. USGS will be responsible for the mission ground system, comprised of flight operations, data processing, and archive. A Thermal Infrared Sensor (TIRS) with two bands with 120-m spatial resolution is being considered for launch on the same platform.

Curtis Woodcock [Boston University—*Landsat Science Team Co-Chair*] presented the priorities for the Landsat Science Team. He noted that since the Landsat archive was opened for free download that the number of scenes delivered by the USGS has increased fifty-fold. The team has organized around a number of priority issues, including the impending *data gap* prior to the launch of OLI, future Landsat class missions beyond LDCM, and the Global Consolidated Landsat Archive. Technical working groups have formed to address cloud masking, surface reflectance, and temperature as standard OLI products and carbon mapping and monitoring. Future issues include operational land-cover change monitoring, cloud screening of the Landsat archive data, and definition of long-term sensing scenarios beyond “Landsat 9.”

The session ended with **Bryant Cramer** [USGS] who presented different aspects of USGS involvement with Landsat. Current efforts include developing a multi-source data acquisition plan to mitigate a potential Landsat *data gap* and augmenting the single data stream from Landsat 8. In the latter context, USGS is working with the European Space Agency (ESA) on possible joint operations of Landsat 8 and Sentinel 2. He noted that additional funding is needed for USGS LDCM operations and any *data buys* associated with filling the potential Landsat *data gap*; he also stated that the funding pathway for an operational Landsat program is not evident. Following his talk, there was an animated discussion from the community on the need to build two OLI instruments, while a plan for the future of U.S. land imaging is being formulated; the need for NASA to stay actively engaged in the future of the Landsat program; the requirement for higher temporal frequency from Landsat class observations; and the comparatively rapid deployment of Landsat class systems by other nations.

The afternoon session included a summary of LCLUC-related research findings from the Earth Observing-1 (EO-1) system. **Betsy Middleton** [GSFC—*EO-1 Project Scientist*], and **Robert Wolfe** [GSFC—*Terra Deputy Project Scientist for Data*] presented on the state of MODIS instruments and land products.

Diane Wickland [NASA HQ] presented on the Decadal Survey land science rationale, plans, and mission phasing. Of particular note for the LCLUC community are the near-term *Tier 1* missions—Soil Moisture Active and Passive (SMAP) and Deformation, Ecosystem and Dynamics of Ice (DESDynI)—and their respective capabilities for soil moisture and vegetation structure mapping. In the mid-term, the *Tier 2* Hyperspectral Infrared Imager (HypIRI) mission will have capabilities for moderate resolution (60 m) thermal and hyperspectral remote sensing. The community was encouraged to participate in science definition and development of requirements through workshops planned over the next 18 months. Concerns from the community about the need for balance between these new experimental missions and systematic observations were noted.

Future Directions Session

Chris Justice [University of Maryland College Park—*LCLUC Project Scientist*] and **Garik Gutman** led the final session of the workshop, which focused on future directions for LCLUC. The program has demonstrated, through the use of NASA satellite data, that over the past few decades rapid changes in land use and land cover have occurred at local to regional scales with significant impacts on the environment and social systems. These data have been used in part to initialize projections of future land-use change. **However, the impact of LCLUC on social systems has received relatively little attention to date. How the research community should address social vulnerability or resilience needs further consideration.**

Climate change with an emphasis on mitigation through land-use practices and land-use adaptation is becoming a major program focus. Program management recognizes the need for the human dimensions aspect of proposed LCLUC research to be integral to the research question, rather than an appendage. There is a growing body of research within the program on the role of institutions and policy impacts on LCLUC, which warrants synthesis. As a result of recent selections, urban growth is receiving more attention from the program. Regional focus for the program is currently on South Asia but is turning to South America, beyond the Amazon.

With respect to observations, the community is encouraged to take advantage of the newly opened Landsat archive and the 2005 GLS datasets. Increased international cooperation on Landsat class data exchange needs to be developed prior to the launch of the LDCM, and the continuation of the Landsat program will be critical to the LCLUC research program. The program also will need to consider a future fine-resolution *data buy* in support of LCLUC process studies.

The next LCLUC Team Meeting will be convened jointly with the International Monsoon Asia Integrated Regional Study Program, the Northern Eurasia Earth Science Partnership Initiative, and the GEO Agricultural Monitoring Task. The meeting will focus on land-use change in dryland systems and will be held in Almaty, Kazakhstan, September 15-20, 2009. ■



On June 5, 2009, a mountainside collapsed in the Chongqing region of southern China. The landslide dropped some 420 million ft³ (12 million m³) onto several homes and an iron ore mine, trapping dozens of people. According to a June 18 report from Xinhua News Agency, 64 people remained missing. This photo-like image was captured by the Advanced Land Imager (ALI) onboard NASA's Earth Observing-1 (EO-1) on June 17, 2009, revealing a giant scar of bare land that fans out toward the south on an otherwise vegetated landscape. To view this image in color please visit: earthobservatory.nasa.gov/IOTD/view.php?id=38978. **Credit:** NASA's Earth Observatory.