NASA LCLUC Spring Science Team Meeting

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The NASA Land-Cover and Land-Use Change (LCLUC) Program Science Team Meeting was held April 4-6, 2007, at the University of Maryland. Approximately 150 participants joined the meeting which was focused on land-use and climate interactions. The agenda from this meeting as well as past Science Team meetings can be found on the LCLUC website at ***ftp://ftp.iluci.org/LCLUC_APR2007/1_agenda_lcluc_apr2007.pdf.***

Opening Remarks

Garik Gutman [NASA Headquarters (HQ)—*LCLUC Program Manager*] opened the meeting with a status report describing the LCLUC Program vision, linkages with the other NASA programs and the Climate Change Science Program (CCSP), external international linkages and the current make-up of the LCLUC Program. He also reviewed the meeting format (structured as scientific overview presentations, programmatic presentations, and poster presentations) and detailed expectations. In addition, Gutman also discussed program activities, public relations, reporting, education opportunities, and data issues. He also noted some current and forthcoming events and shared news concerning ongoing projects and research announcements, including an update on the current status of Landsats 5 and 7 and the Mid-Decadal Global Land Survey (MDGLS). Gutman also mentioned the contributions of LCLUC to the Northern Eurasia Earth Science Partnership Initiative (NEESPI) and the Monsoon Asia Integrated Regional Study (MAIRS) programs.

Chris Justice [University of Maryland, College Park (UMCP)—*LCLUC Program Scientist*] followed with a presentation on how land use-climate interactions could be developed within the LCLUC Program. LCLUC and related NASA programs continue to fund research on the role of land use and biogeochemical cycles. The 'land use' term in the global carbon cycle is well recognized and a topic of continued research in the Carbon Cycle Program. Land use also provides a means by which we can reduce greenhouse gas emissions by sequestering carbon. (This particular application requires a strong science underpinning.) The impacts of land-use change in altering regional climate is an area currently receiving more attention, and a few projects were selected in the last funding cycle. The impacts of future climate change on land use in the context of sustainability and land use as a means to adapt to climate change and reduce human vulnerability have received less attention, and are areas that warrant development by the program and partner agencies in the U.S. CCSP. There is also an increasing recognition of the importance of models addressing multiple stressors. This includes the simultaneous impacts and feedbacks of land-use change (caused largely by socio-economic changes), and climate change (caused by regional land-use change and global warming).

LCLUC Science Team Meeting attendees.

Example Presentations

A total of 18 overview presentations were given during the meeting, including *State of the LCLUC Science* presentations and *Programmatic* presentations. Examples of the state of the science reviews, which provide a compilation of research from science team members are as follows.

Roger Pielke [University of Colorado] gave an overview of land use-climate interactions studies. He showed that land use, through its the role in the water, energy, and carbon cycles and trace gas and aerosol effects, has a first-order role in human and natural climate forcing and feedbacks. Pielke identified global atmospheric teleconnections due to land-use/land-cover change, which appear to alter weather and other aspects of the climate system as much or more than would occur due to the radiative effect of doubling carbon dioxide.

Hank Shugart [University of Virginia] gave an overview of carbon dynamics in boreal forests, showing the interaction between plant and soil processes, disturbances and climate change. He showed the synergy between LCLUC projects providing satellite observations and process studies from the leaf and plant level (e.g. photosynthesis, growth and mortality), through the stand level (e.g. regeneration, competition) to landscape and regional scales (e.g. dispersal, fire and logging disturbances). These projects provide the foundation for a system for monitoring and validating the distribution and change in land cover across Northern Eurasia. The fusion of data from different sensors with different resolutions and capabilities provides an increased capability to represent land cover dynamics as an essential part of the Earth's systems.

Irina Sokolik [Georgia Institute of Technology] gave an overview of aerosols and land-use interactions. She made the case for new approaches to develop dynamic emission algorithms based on a process-oriented description of land use- and ecosystems-dynamics and climate change. Sokolik explained the state of the art in aerosol modeling and outlined the key aerosol- and air pollution-induced processes and feedbacks that have been affecting the energy, water, and carbon fluxes over Northern Eurasia. She identified distinct trends in aerosol sources and spatial and temporal variability, due to region-specific climatic, economical, and political changes**.** She explained the role of aerosols within an integrated regional study under the International Geosphere-Biosphere Program (IGBP).

Andy Hansen [Montana State University] gave an overview of biodiversity, land-use, and climate interactions. He gave examples of studies at three scales, showing how local case studies can lead to a better understanding of processes and an understanding of global trends. Local scale predictive land-use studies allow society to visualize change and enable the development of policy that can improve local sustainability. At the regional scale, studies enable the development of theory and testing of continental-to-global scale models. These studies can help revise conservation strategies and improve monitoring to inform management and assess the impact of management policies. Future directions for land-use and biodiversity research include providing a spatial dimension for conservation biology, quantifying the impacts of population growth and consumption, evaluating possible unpredicted thresholds of land use change, and possible future land use options. Hansen suggested that in the context of biodiversity, land-use change needs to be elevated along with climate change to inform public and policy debates.

Jon Foley [University of Wisconsin] gave an overview of agriculture as a major force in the Earth System. He explained that agriculture has already altered the biosphere as much as projected climate change. Foley stated that 40% of the Earth surface has been converted to agriculture and that agricultural water use has tripled in the last 50 years, resulting in a massive release of excess nutrients into aquatic systems. He pointed out that land-use change and climate change are happening together, and that although satellite data are useful for identifying and monitoring land cover, fusion with socioeconomic data are needed to better understand land use. In the past 40 years, agriculture has expanded but that intensification has been greater. Current global data products are inadequate for capturing land use or quantifying the processes and increased attention is needed on land-use practices and agricultural management. Land-use practices are changing quickly and major changes can be foreseen in the coming years with increasing use of biofuels, increasing demand for animal feed, and increasing participation in global markets. Foley concluded by saying that the current focus on the carbon dioxide-climate change connection is shortsighted and that a more comprehensive framework is needed to explore changes in the Earth System.

Billie L. Turner II [Clark University] presented an overview of research on landscape vulnerability and resilience. He started by outlining the sustainable land architecture emerging from the International Geosphere-Biosphere Programme/International Human Dimensions Programme on Global Environmental Change (IGBP/IHDP) Global Land Project in the broader framework of sustainability science. Turner suggested that the latter will be the context for the next multi-decade climate and global change and development research agenda. He showed how LCLUC is poised to be a foundation for sustainability science, particularly in the area of human vulnerability.

Five others gave *state of the science* presentations including:

- **Amber Soja** [NASA Langley Research Center] who spoke on fires and climate interactions in the boreal zone;
- **Matt Hansen** [South Dakota State University] who spoke on multi-resolution forest monitoring;
- **Skip Walker** [University of Alaska, Fairbanks] who spoke on climate, sea ice, land cover, and human interactions in the Arctic Zone;
- **Walter Chomentowski** [Michigan State University] who spoke on tropical deforestation and carbon interactions, and
- **Marc Simard** [NASA/Jet Propulsion Laboratory] who spoke on advances in microwave data for land-use studies.

Three of NASA's major regional research programs place an emphasis on LCLUC research. The group heard from:

- **Daniel Nepstad** [Woods Hole Research Center] who represents the Large-Scale Biosphere-Atmosphere experiment in Amazonia (LBA) program;
- **Pavel Groisman** [NOAA] who represents the NEESPI programs; and
- **Sasan Saatchi** [NASA/JPL] who represents the North American Carbon Program.

In addition to the overview presentations, 48 posters were presented at the meeting during an invited poster session, which included results from both the New Investigator Program and the Graduate Fellowship Program.

Programmatic Presentations

Programmatic presentations were given to brief the team on recent developments**.**

Ed Sheffner [NASA HQ] summarized the agricultural component of the NASA Applications Program and described the recent changes in the Applications Program.

Jeff Masek [NASA Goddard Space Flight Center (GSFC)] presented the status of the USGS/NASA Mid-Decadal Global Land Survey which is aimed at providing a global Landsat data set from Landsat 5 and Landsat 7 for the 2004-2007 period. He described the progress that has been made with scene acquisition for that period, including data from selected international ground stations, the complexity associated with using composited data from the malfunctioning Landsat 7, and options for product generation from the baseline data set.

Jim Irons [NASA GSFC] presented the Landsat Data Continuity Mission status and on the first meeting of the U.S.Geological Survey (USGS) Landsat Science Team in Sioux Falls and the status of the NASA Landsat Data Gap Study.

Martin Herold [Friedrich Schiller University] presented the international Global Observations of Forest and Land Cover Dynamics (GOFC/GOLD) Deforestation Initiative and the FAO Land-Cover Classification System (LCCS).

Sasan Saatchi [NASA JPL] gave an overview of LCLUC projects in the North American Carbon Program.

Breakout Discussion Groups

Two breakout discussion groups were held: one group to discuss research priorities for land-use and climate interactions and another to discuss program priorities for land-cover and land-use change data. In addition to discussing priorities, the groups were tasked with identifying steps to improve data availability and access, obstacles impeding progress, near-term opportunities, and future recommendations. Findings from the two breakout discussion groups are outlined below.

Land-use and Climate Interactions

Co-Chairs: Robert Dickinson [Georgia Institute of Technology] and **Pavel Groisman** [NOAA]

Global changes are driven by events happening at the local and regional scales, but from a climate modeling perspective, we tend to think about them at the global scale because the atmosphere serves as a mixing bowl. The accumulation of events at the local scale, particularly the human impacts, are what matter most. There is a well-recognized need for a better understanding of the processes underlying the responses seen and for a better characterization of observed variability in land-change dynamics.

Before we can predict, we have to be able to describe the processes shaping what is happening now and what happened in the past. We need to know the sources of the finer scale variability of the processes of interest, spatial variability of land use, vegetative cover, cryosphere dynamics, hydrologic variability, and aerosol production. We also need to develop the ability to reliably reproduce and predict extreme events in regional analyses. We need to move beyond the biophysical component and develop the biogeochemical connections to the atmosphere and hydrosphere from land-use change processes with an ultimate goal of incorporating them into the coupled global Earth models.

For land-use impact studies, LCLUC researchers should not use a single model output of future predictions but rather an ensemble of global climate model (GCM) outputs, relying on converging lines of evidence. Our models and resulting products need to be able to com-

municate with each other using similar remote sensing products and generating the outputs that can be assimilated (adopted) by other models. A vision concerning the integration of various types of models at different scales into the whole should be developed. Multi-model comparison should be undertaken to estimate models' uncertainty and to facilitate use of their results. We need fully integrated human-environment models at all scales and a continuous supply of accurate data to support model development and validation.

The group's recommendations to the LCLUC program management were as follows:

- We want to maintain a balanced program and seek to do this by focusing on enhancing LCLUC data acquisition, studying projections, processes, feed backs between processes, and securing links with the global change modeling community.
- We need to encourage and strengthen international and interagency program collaboration.
- We should focus on regional climate prediction on a shorter time scale (10-50 years) with fully coupled aerosols and biogeochemistry because this currently seems to be the most promising strategy.
- We need a better understanding of the ways in which societal processes and feedback loops (e.g., population movements, agricultural practices, road development, etc) will be accounted for in coupled land-use and climate models.
- We need a better understanding of how regional scale feedbacks and impacts interact with global scale changes.

Land-cover and Land-use Change Data Priorities

Co-chairs: Curtis Woodcock [Boston University] and **Matt Hansen** [South Dakota State University].

Landsat class observations are essential to the success of the LCLUC Program. The approach by the science community is to use a time series of Landsat class data at the regional scale. Although there are large volumes of data in the archives, the current costs of Landsat 7 data are an obstacle for this approach. The generation of global datasets (surveys) by NASA and more recently in cooperation with USGS, which are available free of charge, has proven to be extremely helpful to the science community. Continuity of a Landsat class of measurements between now and the launch of the Landsat Data Continuity Mission is not assured, and NASA should seek to fill this data gap through a virtual constellation that includes international assets. In particular, NASA should be prepared to provide observations in support of a 2010 global decadal survey.

The group endorsed the transition of the Landsat Program to operational status and advocated improved security of measurement scenarios through use of a constellation of low-cost satellites. It was noted that a single Landsat-style satellite, although an important contribution, is a mission concept developed for the 1970's and will be insufficient to meet the current needs of the LCLUC research and applications community. The single greatest improvement to our ability to monitor change at the Earth's surface would be an improvement in temporal resolution of the Landsat class data. The four-to-five acquisitions per month demonstrated by the Advanced Wide Field Sensor (AWiFS) instrument is considered a major improvement.

The success of the LCLUC Program also remains dependent on continued production of science quality products from the Moderate Resolution Imaging Spectroradiometer (MODIS) and eventually the Visible Infrared Imaging Radiometer Suite (VIIRS), including sufficient overlap between the two missions to facilitate inter-calibration and product intercomparison. Given the current plans for Environmental Data Records from VIIRS, it will be necessary for NASA to support the generation of science-quality land-cover related products from VIIRS. As land observations migrate to operational status, we encourage NASA to ensure coordination across scales and wavelengths in support of land science. We endorse the recommendations of the National Research Council's *Decadal Survey* with respect to the need for a future mission which would include a lidar and a radar.

Closing Remarks

Garik Gutman [NASA/HQ] concluded by summarizing the meeting and adding some observations. The LCLUC Program supports research at the interface between remote sensing, physical science, and the human dimension of global change. The distinction between the Terrestrial Ecology and LCLUC programs is that while both programs address aspects of ecological problems, the LCLUC is unique in that it pays attention to managed ecosystems involving the human dimensions—i.e. with explicit inclusion of social science. In the next phase of funding, the program is moving toward larger projects addressing regional-scale and more integrative problems. While fewer total projects will be funded, there still remains room for smaller projects to be included in the program and develop links to established teams.

The Science Team Meeting agendas are built around geographic and topical breakdowns. The meeting format is currently a series of overview presentations with team member contributions listed. Spring meetings are held in the Washington, DC area, while fall meetings will be held abroad to facilitate greater participation of regional experts and international collaborators and managers.

Future areas for the development of the program are as follows:

- integration of LCLUC processes in regional and global climate models;
- International Polar Year research;
- involvement in new interdisciplinary areas including land use-human health relationship;
- improved predictive land-use modeling—regional focus on northern and southern Eurasia; and
- increased involvement of social science.

Chris Justice [UMCP] followed Gutman and emphasized the need for continued and active participation by LCLUC scientists in the U.S. CCSP and the need to initiate research on the adaptation of humans and land-use systems to climate change, sustainability and human livelihoods.

Future Meetings

The upcoming Joint NEESPI/LCLUC Science Team Meeting will be held September 16-20, 2007, in Urumqi, located in the western drylands of China. The focus of the meeting will be on dryland land-use systems. The meeting will provide an international forum for the exchange of scientific findings and discussion of research priorities and data coordination and exchange. More information concerning logistics, agenda, and registration, along with presentations and posters from the above meeting can be found on the LCLUC website at *lcluc.hq.nasa.gov*. We plan to hold the Spring 2008 LCLUC Science Team Meeting in conjunction with the Carbon Cycle and Ecosystems Focus Area Meeting in the Washington, DC area. ■

Although forest clearing for pasture is the primary driver of Amazon deforestation in the state of Mato Grosso, Brazil, a new study led by scientists at the University of Maryland showed that large-scale mechanized agriculture, mostly for soybeans, is rapidly becoming a major force behind forest loss in the region. A related study led by scientists at NASA's Goddard Space Flight Center indicates that what people do with the land—whether they leave it bare, plant crops, or convert it to pasture—influences the climate in different ways. Scientists fed satellite data on the area and type of forest conversion in Mato Grosso into computer models to predict the effect on climate. Leaving the ground bare has the most significant influence, raising temperatures up to 3° F. Croplands have the second most significant impact, followed by pastures.

This pair of images shows large clearings made in the Amazon Rainforest in the state of Mato Grosso, Brazil, between 2001 and 2006. A river meanders along the bottom right corner of the images, surrounded by forest, which appears medium-gray. In 2001, a few large clearings (light-gray rectangles) appeared. By 2006, the area cleared in the scene appears to have roughly tripled. Satellite observations such as these, which are from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite, combined with on-the-ground surveys, help scientists monitor forest changes over time.

Credit: NASA images by Robert Simmon, based on data provided by the NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team