THE NASA LCLUC PROGRAM

An Interdisciplinary Approach to Studying Land–Cover and Land–Use Change

The NASA LCLUC Program

An Interdisciplinary Approach to Studying Land-Cover and Land-Use Change

Contact Information

Program Manager
Dr. Garik Gutman
NASA Headquarters
ggutman@hq.nasa.gov

Program Scientist
Dr. Christopher Justice
University of Maryland, College Park
justice@hermes.geog.umd.edu

LCLUC Website
http://lcluc.hq.nasa.gov
NASA Earth Science Website:
http://nasascience.nasa.gov/earth-science

NASA LCLUC Program: Contents

The LCLUC Program, through an interdisciplinary approach, is developing and using NASA remote sensing technologies to improve understanding of human interactions with the environment and provide a scientific foundation for understanding the sustainability, vulnerability and resilience of human land use and terrestrial ecosystems.

Program Goals

- Understand the processes, interactions and feedbacks of land-cover and land-use change with the carbon and water cycles, the climate system and society.
- Understand the impacts of land-use change on ecosystems, biodiversity, environmental goods and services and the management of natural resources.
- Understand the interactions between land use and climate change, including mitigation and adaptation and the associated impacts on Earth systems and society.

Program Technical Infrastructure Objectives

- Secure the satellite observations needed to enable the advancement of land-use science.
- Develop the capability to perform repeated global inventories of land use and land cover from space.
- Develop the capability to model and predict land-use and land-cover changes.
- Enable regional land-cover and land-use science networks to contribute to the program.

LCLUC Key Science Questions

1. Where are land-cover and land-use changes taking place, to what extent and over what time-scale?
2. What are the causes and consequences of LCLUC?
3. What are the projected changes of LCLUC and their potential impacts?
4. What are the impacts of climate variability and changes on LCLUC, and what is the potential feedback?

NASA LCLUC research contributes to the U.S. Climate Change Science Program by providing the scientific underpinning for the provision of land-use and land-cover data and information, products and services, models and tools for multiple applications users including scientists, resource managers, decision and policy makers.

The program consists of peer-reviewed projects which are funded for two to four years. Periodic announcements of opportunity call for proposals addressing selected research themes which are aligned with the overall research strategy of the U.S. Climate Change Science Program. These studies include the causes, impacts and prediction of land-use change and the development of methods to quantify and characterize land-cover and land-use change. The program fosters an integration of physical and social science and the funded projects often result in societal benefit. All of the projects utilize remotely sensed data, addressing regional-to-global scale issues. Recent emphasis has been given to the role of land-use change in the climate system, both in terms of its contribution to biogeochemical cycles and water and energy fluxes; the impacts of climate change on land use and sustainability and how land use will adapt to a changing climate.

Science Team

The LCLUC Science Team consists of Principal Investigators (PI's) who are funded by the NASA LCLUC program directly or who are undertaking LCLUC research supported through other NASA programs (e.g. Carbon Cycle, Water Cycle, Data and Information Systems, Applications and Instrument Teams). The LCLUC program holds biannual Science Team Meetings (one general workshop in the D.C. metro area and one thematic workshop hosted by a regional partner), which provide an opportunity for PI's to present their research findings, learn about new NASA national and international program developments, and to give feedback to the program management on future missions and program direction. These meetings provide an opportunity for networking and collaboration which has resulted in community led synthesis studies, thematic workshops, books, journal special editions and increased international collaboration. New investigators and graduate fellows are encouraged to attend and present posters at these meetings and participate in articles, thematic workshops, special editions and team proposals.

NASA LCLUC Program's Contribution to the International polar year

Changes in land- and ice cover in the Arctic are among the earliest indicators of the Earth surface's response to climate warming. Climate change is expected to accelerate, affecting both the arctic ecosystem as well as socioeconomic infrastructure. Moreover, changes in the Arctic are predicted to affect climate and people on a global scale. The book "Arctic Land Cover and Land Use in a Changing Climate: Focus on Eurasia" is a compilation of results from studies on land-cover and land-use changes and their interactions with biogeochemical and water cycles, atmospheric aerosol, and human and wildlife populations in the Northern Eurasian Arctic. NASA, the National Science Foundation, the Russian Academy of Sciences, the Academy of Finland and other European institutions have supported these studies. This volume is the NASA Land-Cover Land-Use Change Program's contribution to the International Polar Year (IPY) program, now in its final stage. It was written by an international team consisting of scientists from the USA, Europe and Russia under the auspices of the Northern Eurasia Earth Science Partnership Initiative (NEESPI). This book should be of interest to those involved in studying recent and ongoing changes in the Arctic, be they senior scientists, early career scientists or students.

Arctic Land Cover and Land Use in a Changing Climate: Focus on Eurasia
in press, Springer publishing

Chapter 1. Introduction: Climate and land-cover changes in the Arctic
G. Gutman, P. Groisman, and A. Reissell

Chapter 2. Recent changes in Arctic vegetation productivity: Satellite observations and simulation model predictions
S.J. Goetz, H.E. Epstein, D. Alcaraz, U. Bhatt, A. Bunn, J. Comiso, G.J. Jia, J.O. Kaplan, H. Lischke, A. Lloyd, Q. Yu, and D.A. Walker

Chapter 3. High-latitude forest cover loss in Northern Eurasia, 2000 to 2005
P. Potapov, M.C. Hansen, and S. Stehman

Chapter 4. Characterization and monitoring of tundra-taiga transition zone with multi-sensor satellite data
G. Sun, K.J. Ranson, V.I. Kharuk , S.T. Ima, and M.M. Naurzbaev

Chapter 5. Vegetation cover in the Eurasian Arctic: Distribution, monitoring, and role in the carbon cycling
O. Krankina D. Pflugmacher, D. Hayes, A.D. McGuire, M. Hansen, T. Hame, V. Elsakov, and P. Nelson

Chapter 6. The effects of land-cover and land-use change on the contemporary carbon balance of the arctic and boreal terrestrial ecosystems of northern Eurasia
D.J. Hayes, A.D. McGuire, D.W. Kicklighter, T.J. Burnside, and J.M. Melillo

Chapter 7. Interactions between land-cover/use change and hydrology
A.I. Shiklomanov, T.J. Bohn, D.P. Lettenmaier, R.B. Lammers, P. Romanov, M.A. Rawlins, and J.C. Adam

Chapter 8. Eurasian reindeer pastoralism in a changing climate: Indigenous knowledge and remote sensing
N.G. Maynard, A. Oskal, J.M. Turi, S.D. Mathiesen, I.M.G. Eira, B. Yurchak, V. Etylin, and J. Gebelein

Chapter 9. Cumulative effects of resource development, reindeer herding, and climate change on the Yamal Peninsula, Russia and contrasts with the Alaska North Slope
D.A. Walker, B. C. Forbes, M.O. Leibman, H.E. Epstein, U.S. Bhatt, J.C. Comiso, D.S. Drozdov, A.A. Gubarkov, G.J. Jia, E. Kaarlejärvi, J.O. Kaplan, A.V. Khomutov, G.P. Kofinas, T. Kumpula, P. Kuss, N.G. Moskalenko, M.K. Raynolds, V.E. Romanovsky, F. Stammler, and Q. Yu

Chapter 10. Interactions of Arctic aerosols with land-cover and land-use changes in Northern Eurasia and their role in the Arctic climate system
I.N. Sokolik, J. Curry, and V. Radionov

Chapter 11. Interaction between environmental pollution and land-cover/land-use change in Arctic areas
J. Derome and N. Lukina

Chapter 12. Outstanding scientific challenges for land-cover and land-use research in the Arctic region
G. Gutman and C. Justice
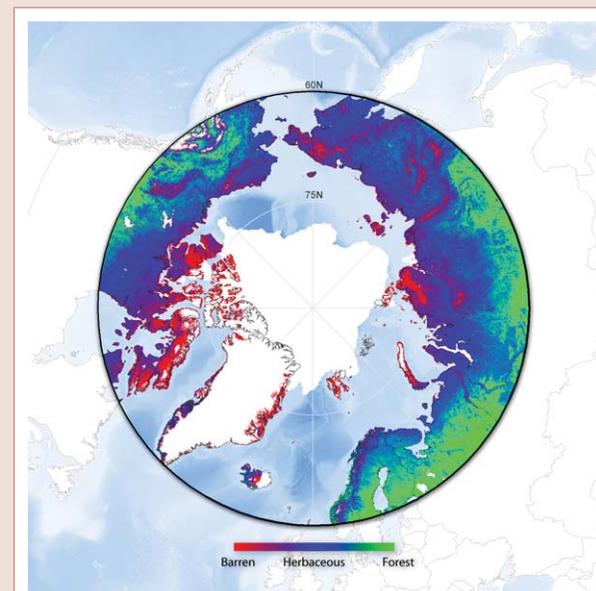
A color composite of the MODIS vegetation continuous fields indicating the combination of tree and herbaceous vegetation cover and bare ground. Green hues indicate dominance of tree cover, blue hues indicate dominance of herbaceous vegetation (tundra), and red hues indicate bare ground. Land and national borders are shown and white areas represent ice, including the polar ice cap as recorded in September 2008. The figure is based on Goetz, et al. (this volume), with artwork by G. Fiske. The MODIS vegetation continuous fields product is available at http://glcf.umiacs.umd.edu/data/vcf/.

For more information: http://lcluc.umd.edu/Program_Information/ipy.asp

Sample Project: Establishing a global forest monitoring capability using multi-resolution and multi-temporal remotely sensed data sets

Matt Hansen (PI), South Dakota State University, Steve Stehman, SUNY-ESF, College of Environmental Science and Forestry, Tom Loveland, USGS, Jim Vogelmann, USGS and Mark Cochrane, SDSU

Quantifying rates of forest-cover change is important for improved carbon accounting and climate change modeling, management of forestry and agricultural resources, and biodiversity monitoring. A practical solution to examining trends in forest cover change at global scale is to employ remotely sensed data. Satellite-based monitoring of forest cover can be implemented consistently across large regions at annual and inter-annual intervals. This research extends previous research on global forest-cover dynamics and land-cover change estimation to establish a robust, operational forest monitoring and assessment system. The approach integrates both MODIS and Landsat data to provide timely biome-scale forest change estimation. This is achieved by using annual MODIS change indicator maps to stratify biomes into low, medium and high change categories. Landsat image pairs can then be sampled within these strata and analyzed for estimating area of forest cleared.

Results for the humid tropics reveal that 27.2 million hectares of forest were cleared from 2000 to 2005, with nearly 50% of this change occurring in Brazil (see figure at right). Indonesia was a distant second in forest loss, accounting for 12% of the biome total. The approach enables regional inter-comparisons such as these and can be implemented repeatedly over time in a monitoring context. For example, a national-scale study of Indonesia using the method with AVHRR forest loss indicator maps and Landsat sample blocks for the 1990 to 2000 epoch estimated average clearing to be 1.78 million hectares. Clearing from 2000 to 2005 averaged 0.71 million hectares per year. This dramatic downturn may be related to the drivers of forest clearing having changed at the turn of the century, including political and social upheaval, an economic downturn, and the occurrence of widespread, human-induced fire during the ENSO event of 1997 and 1998.

Boreal forest clearing from 2000 to 2005 actually
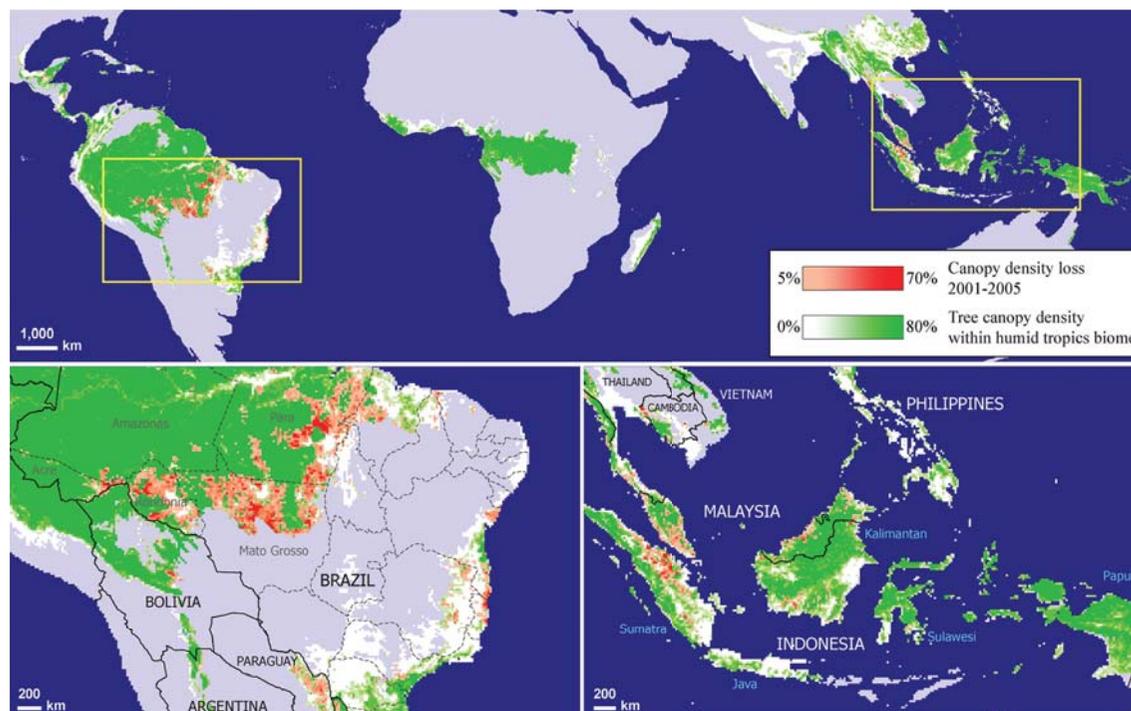
Forest clearing and forest cover in the humid tropical forest biome, 2000-2005. Total forest clearing over the study period is estimated to be 27.2 million hectares (SE 2.28 million hectares). Clearing is spatially concentrated with 55% of all clearing occurring within 6% of the biome.

exceeded that of the humid tropics, totalling 35.1 million hectares. The proportion of year 2000 forest lost was 4.02%, compared to 2.36% for the humid tropics. In the boreal biome, fire is a major cause of forest cover loss and was estimated to account for nearly 60% of the total. As a percent of year 2000 forest cover, forest loss in North America was nearly twice that of Eurasia (5.63% to 3.00%).

Overall, the method enables global, biome and targeted national/regional-scale quantification of forest cover change. The method requires less effort than exhaustive mapping approaches, includes a measure of uncertainty, and through regression estimation, provides a spatial depiction of the estimated change.

Sample Project: Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia

D.A. Walker (PI) University Alaska Fairbanks, U.S. Bhatt, V. Romanovsky, G. Kofinas, U. Alaska Fairbanks, H.E. Epstein, University of Virginia, J. Comiso, NASA Goddard, M. Leibman, N. Moskalenko, A. Gubarkov, A. Khomutov, Earth Cryosphere Insitute, Moscow, B.C. Forbes, T. Kumpula, and F. Stammler, University of Lapland, Rovaniemi

Land cover changes in the Yamal Peninsula region in northwest Siberia are typical of the sorts of changes that are likely to become much more common in tundra areas of Russia and the circumpolar region within the next decade. Currently, gas development is concentrated the Bovanenkovo Gas Field in the central part of the Yamal Peninsula, but there are still large undeveloped areas that are pasturelands to the reindeer of the nomadic Nenets people. The existing oil and gas activities and changes to Russian political-economic structure over the past 30+ years have had profound effects on the social-ecological systems of the Nenets people and the prospect of a rapidly expanding infrastructure network and changes in climate further threaten their way of life. This NASA funded NEESPI project has brought together a collaborative team of US, Russian and Finnish scientists to examine the cumulative effects of resource development, climate change, and traditional land use. The goal is to develop tools to better predict future change by combining scientific and traditional knowledge of the landscapes, detailed field observations, socio-economic analyses, remote sensing, climate change analyses and vegetation-change models.

The larger value of an analysis of cumulative effects on the Yamal Peninsula will be in the lessons learned and the applications of those lessons to other areas of potential development in the Arctic.

Recent Publication: Walker, D.A., Forbes, B.C., Leibman, M.O., Epstein, H.E., Bhatt, U.S., Comiso, J.C., Drozdov, D.S., Gubarkov, A.A., Jia, G.J., Kaarlejarvi, E., Kaplan, J.O., Khomutov, A.V., Kofinas, G.P., Kumpula, T., Kuss, P., Moskalenko, N.G., Raynolds, M.K., Romanovsky, V.E., Stammler, F., and Yu, Q. (in press). Cumulative effects of resource development, reindeer herding, and climate change on the Yamal Peninsula, Russia and contrasts with the Alaska North Slope. In G. Gutman and A. Reissell (Eds.), Arctic land-cover and land-use in a changing climate: Focus on Eurasia. Springer.

Nenets child driving reindeer and sled past a drilling rig in the Bovanenkovo gas field. Photo by Bryan and Cherry Alexander. Yamal Peninsula, Russia.

Yamal Peninsula, Russia. Patrick Kuss and Elina Kärlejaarvi walking in the foreground. Photo by D.A. Walker.

Sample Project: Estimation of seasonal snow cover and glacial area changes in Central Asia during the last 60 years using NASA ESE products and in-situ data

Vladimir Aizen and Elena Aizen (PIs), Arzhan Surazakov, University of Idaho, Siri Jodha Khalsa, University of Colorado, Valeriy Kuzmichenok, IWP, Kyrgyz National Academy of Sciences, Kyrgyzstan

The project focuses on estimation of changes in snow- and glacial-covered areas and simulation of the central Asia river runoff variability. Snow dominates the central Asia hydrology, accounting for 50-70% of the total precipitation and providing 60% of the total river runoff. The annual runoff of the major Tien Shan rivers is on average 67 km^3 yr-1, which includes glacial melt of about 14 km^3 Yr-1 (20%). During droughts, the proportion of glacial runoff increases to 40% of the total as a result of decrease in precipitation and increase in glacier melt. Evaluation of glacier changes during the last thirty years in Tien Shan using aerial photography, Hexagon KH-9, Landsat TM, ALOS/PRISM, ASTER, and SRTM data has revealed glacier covered area reduction of 1,617 km2 (-10.1%), a threefold increase since 1973 in comparison to the rate estimated for 1943-1973 period. The duration of snow melt from the date of maximum snow cover to date of its disappearance reduced by 30 days and in 2007 was equal to 138 days while the seasonal snow covered area in Tien Shan decreased by 15% (approximately 120,000 km2), estimated using AVHRR and MODIS data. The decrease of seasonal snow cover is not a linear process. Further decrease may be accelerated due to increase of rainfall instead of snowfall in early spring months and consequently a lesser heat expenditure for the snowmelt, which initiates early floods and contribute to the warming.

The SGRR model based on GIS DEM distributed meteorological and hydrological parameters from 504 Tien Shan stations predicts increased river runoff by 1.05 times in the next 100 years if air temperature will increase by 3°C and precipitation 1.2 times the current levels. Change in precipitation, rather than air temperature, is the main parameter determining river runoff in the Tien Shan. The maximum ratio for predicted river runoff could reach up to 2.2 and the minimum is predicted to be 0.55 times current levels. However, current glacier recession, while initially considered as a positive factor that increased the river flow, at the end causes the runoff to decrease.

Figure 2. Days with seasonal snow covered areas in Tien Shan evaluated by MODIS Terra data and snow covered areas reconstructed by surface observational, AVHRR and MODIS Terra data.

ten days AVHRR data calibrated with surface observational data | eight days MODIS Terra Data
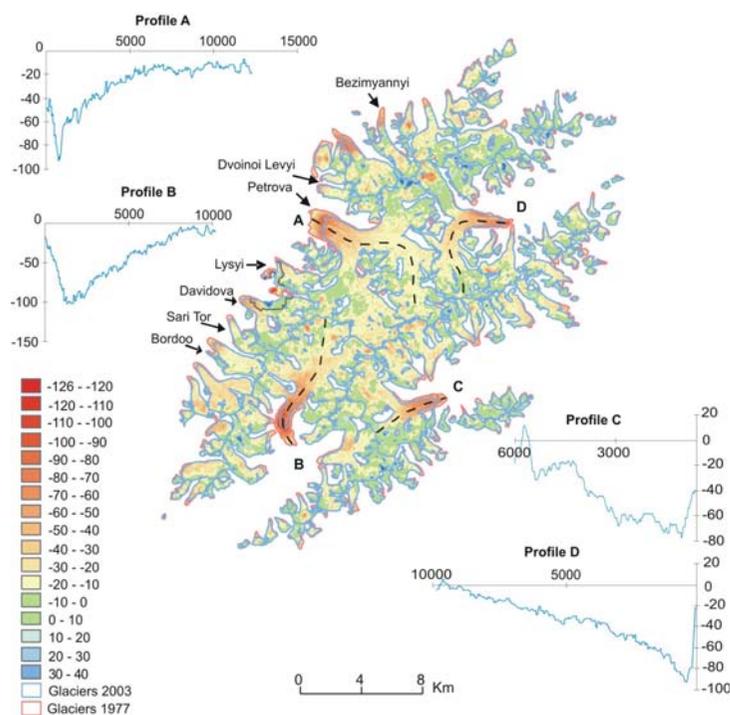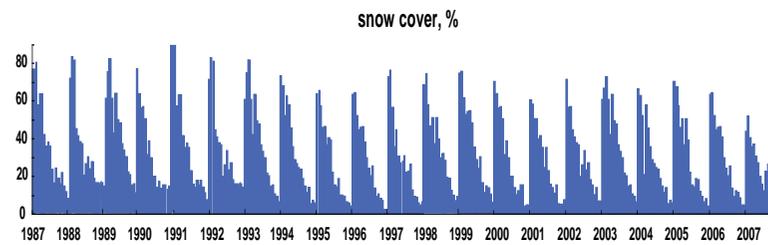

Figure 1. The Tien Shan, Akshiirak glacierized massif (178 glaciers covering 371.6 km2) surface elevation changes (m) evaluated from aerial photographs (1977) and SRTM data (2000) and terminus positions determined from aerial photographs (1977) and ASTER image (2003). A, B, C, D are longitudinal sections of the glacier surface elevation change.

Recent Publication:
Surazakov, A.B., V.B. Aizen, E.M. Aizen. (2008).Towards a new high resolution orthophoto mosaic circa 1976 for Northern Eurasia: Assessing the potential of declassified Hexagon KH-9 images (Tien Shan region, Central Asia case study). Eos Transactions AGU, 89 (53), Fall Meeting Supplement, Abstract GC41A-0701.
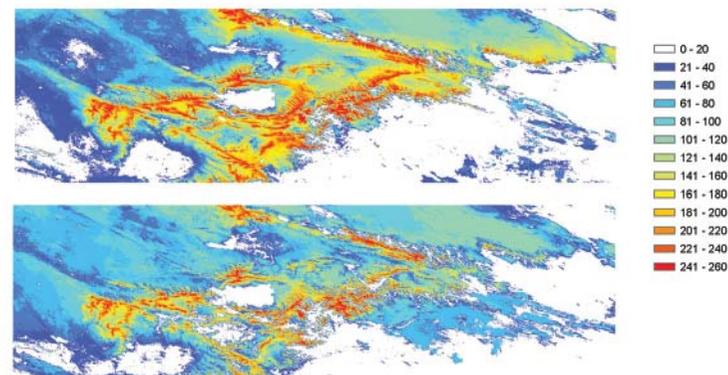
Sample Project: Interactions of edaphic and land-use factors on water resources of the Cerrado region of Brazil

Eric A. Davidson (PI), The Woods Hole Research Center, Gregory P. Asner, Carnegie Institution, Michael Coe, The Woods Hole Research Center, Mercedes Bustamante, University of Brasília, Brazil, Laerte G. Ferreira, Federal University of Goiás, Brazil, Marcos Costa, Federal University of Viçosa, Brazil, and Edgardo M. Latrubesse, Universidad Nacional de La Plata, Agrentina

Deforestation changes the hydrological, geomorphological, and biochemical states of river systems by decreasing evapotranspiration and increasing runoff and river discharge across all spatial scales. Increased runoff and decreased vegetative cover increase erosion and alter river and floodplain morphology as sediments are deposited in side channels and bars. However, attribution of such changes in large rivers is difficult, because deforestation often takes place before instrumentation has begun and is coincident with other human alterations of the river channel, such as the construction of dams and levees. Here we show that deforestation that began in the 1960s in the savannah region of central Brazil (locally know as Cerrado) has altered 62% of the landscape and has significantly altered the morphological and hydrological characteristics of a 120,000km2 watershed of the otherwise unmodified Araguaia River.

Fieldwork and imagery analysis show a 28% increase in sediment transport, 188 million tons of stored sediment, and an increase in the number of sandy bars but a decrease in the number of islands since the 1960s. Observed discharge increased by 25% from the 1970s to the 1990s and simulations with a land surface vegetation and hydrology model indicate that about 2/3 of the increase may be from deforestation. These results provide the first unequivocal quantification of human alterations of the hydrology and geomorphology of a large tropical river. Further, they suggest that similar changes have occurred throughout the 2,000,000 km2, hydrologically important Cerrado region and that many other large tropical rivers are similarly affected by ongoing deforestation.
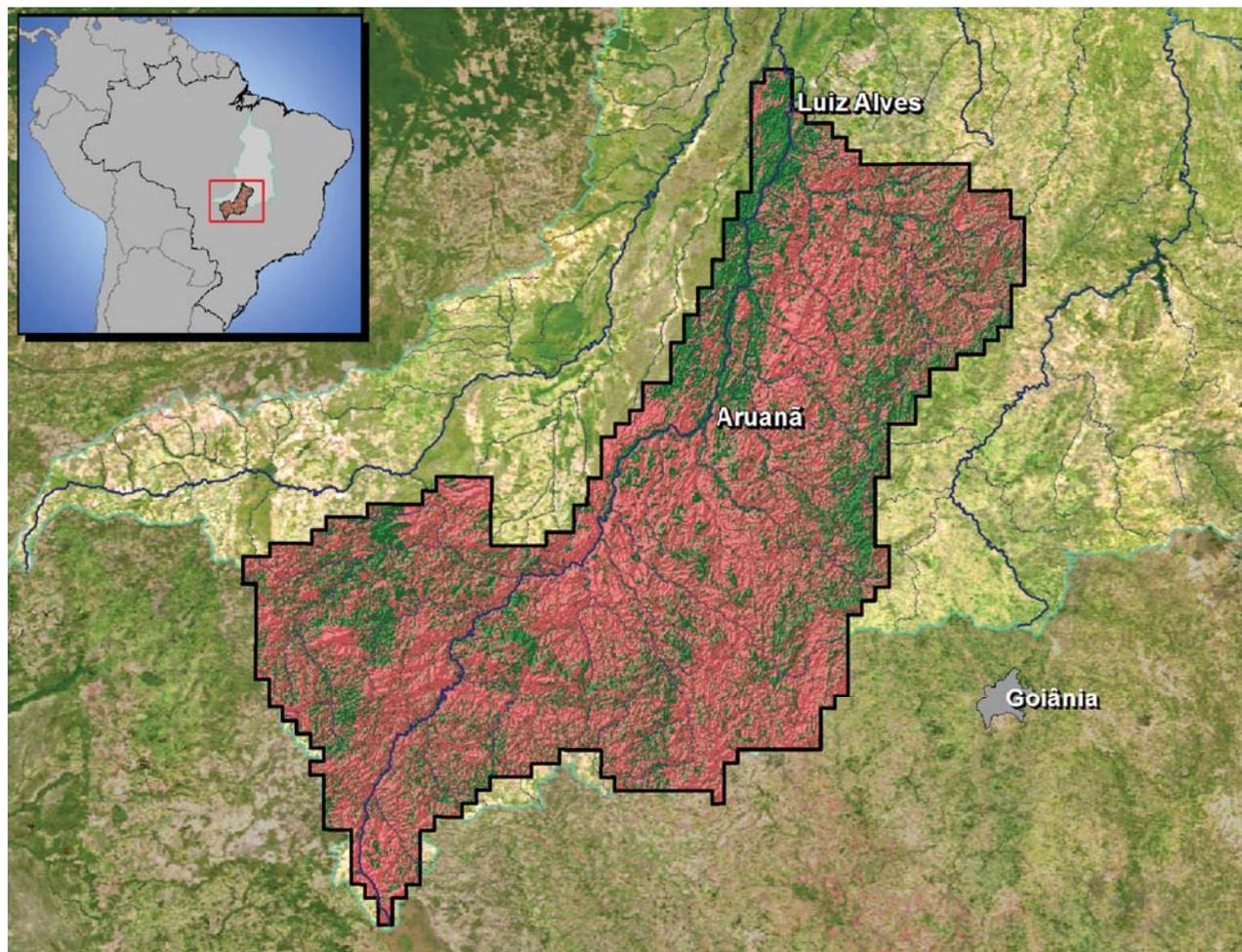
The middle and Upper Araguaia River basis showing CBERS-derived classification of remnant Cerrado (green) and altered lands (pink). About 62% of the basin vegetation and 45% of all riparian zones had been altered by 2006.

Sample Project: Development and sensitivity analysis of high resolution land surface parameters from satellite data and their use in a mesoscale model

Christopher Small (PI), Columbia University, Roni Avissar, Robert Walko, and Kathy Walko, Dept. of Civil and Environmental Engineering, Duke University

The objective of our research is to better understand the effects of anthropogenic land cover modification on regional climate and to improve mesoscale climate model predictive power by incorporating detailed information about land surface properties derived from remotely sensed observations. We accomplish this by eliminating the unnecessary loss of information and introduction of error inherent in low resolution thematic land cover classifications. We focus on urban and suburban areas because the scale and variability of land cover in these areas is not well represented in thematic classifications currently used to drive mesoscale land surface models.

Estimation of physical parameters from Landsat imagery is based on the use of linear spectral mixture models to represent the land surface in terms of water, vegetation, rock, soil and impervious substrates. The spectral mixture model provides decameter (10–100 m) scale estimates of the areal abundance of these biophysical components of land cover in a form that can be validated vicariously with meter scale imagery. By extending the mixture model into the temporal dimension we are able to quantify seasonal to interannual changes in land surface properties and incorporate these changes into the Land Surface Model (LSM). We have developed a systematic methodology for multi-scale, multi-temporal spectral mixture analysis that accounts for the effects of viewing and illumination geometry, topography, sub-pixel shadow as well as atmospheric scattering and absorption. The resulting endmember fractions are used to derive scaleable parameters for the LSM.

These parameters are being tested in two very different LSMs in the Ocean Land Atmosphere Model (OLAM), an Earth System Model with mesoscale and microscale mesh refinement capability. The first LSM, LEAF3, which previously relied on thematic land cover classifications to define physical parameter values, has been modified to use input parameters directly The second LSM, Hi-SVAT, does not differentiate between the above surface components, but instead lumps them together into a single "surface" with properties of albedo, emissivity, roughness, stomatal conductance, leaf area index, and storage capacities for energy and water.

The performance of both LSMs with the new high resolution parameters is evaluated by comparing between LEAF3 and Hi-SVAT, and by validating OLAM simulation results with observations.
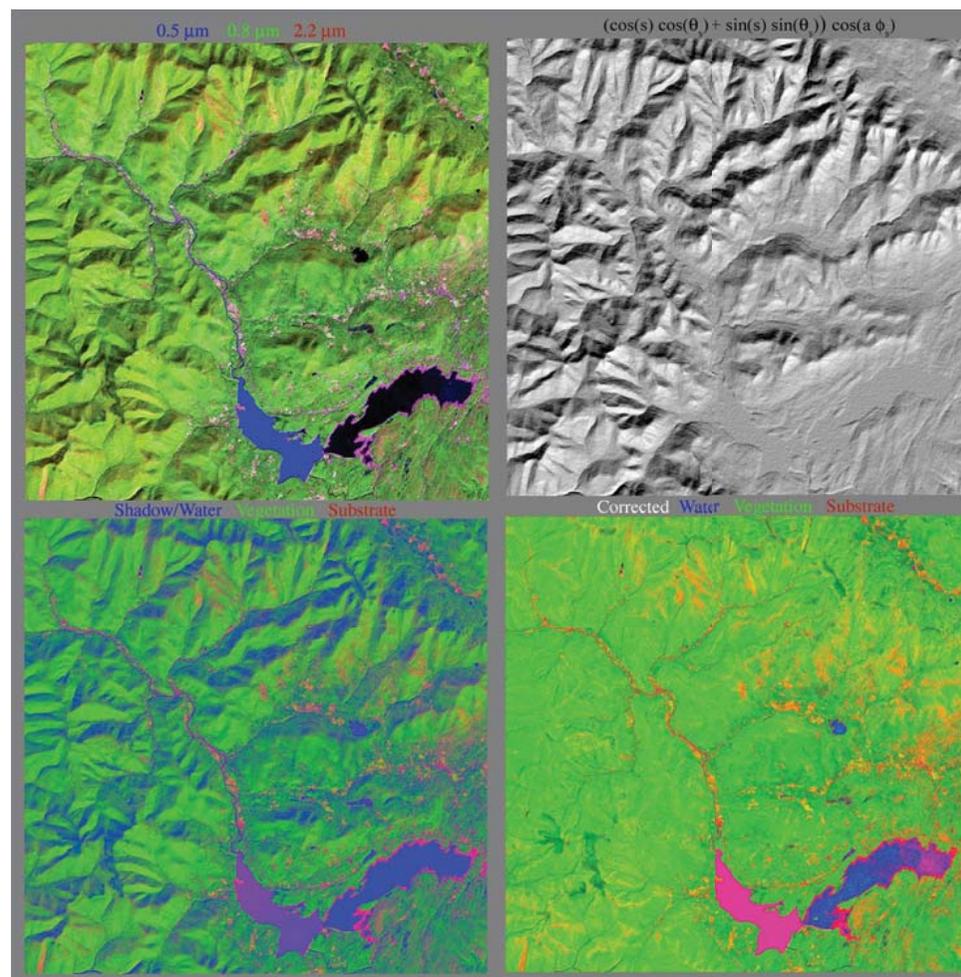
Spectral mixture modeling provides a physical basis for estimation of land surface parameters at multiple spatial and temporal scales without the introduction of error inherent in discrete thematic classifications. Landsat ETM+ imagery of the Catskill Mountains and Ashokan Reservoir can be used to monitor land cover changes in the watershed providing drinking water to New York City. To quantify land cover changes in the watershed it is necessary to derive biophysical land surface properties from radience measurements and correct for effects of topography, atmosphere, subpixel shadow and illumination differences. The result is a set of validated, scaleable inputs for the LSM.

Sample Project: Understanding the role of changes in land-use/land-cover and atmospheric dust loading and their coupling in climate change in the NEESPI study domain drylands

I.N. Sokolik (PI), K. Darmenova, Y. Kurosaki, R. Dickenson, Georgia Institute of Technology, Y. Dai, Beijing Normal University, G. Golitsyn, Russian Academy of Sciences, B. Marticorena, Universités Paris, G. Bergametti, Universités Paris, Yaping Shao, University of Cologne

This project is being conducted by a multi-institutional international science team lead by researchers at Georgia Institute of Technology. The overall goal of this project is to gain an improved understanding of how and to what extent land-cover/land-use changes and varying dust loadings and their interactions have been affecting climate of drylands in the NEESPI study domain over the past 50 years.

Growing evidence suggests that changes in land use/land cover and atmospheric dust loadings are among the key drivers of observed climate change in the NEESPI dryland region. Desiccation of the Aral Sea, conversion of the steppe in Kazakhstan to agricultural fields, and severe desertification of northeast China are just a few examples of land-use changes that have altered the source and emission of dust. The impacts of dust storms are not only regional, but may affect areas thousands of kilometers from their source, making interactions between climate change, land -use and dust aerosols globally relevant. To improve the ability to predict impacts of dust on the climate and environment, one goal of this project it to develop a regional dust modeling system for Central and East Asia. This involves development and implementation of a new dust module DuMo into the NCAR Weather Research and Forecasting (WRF) model. The new dust module includes two different state-of-the-art schemes that explicitly account for land properties (including vegetation and soil moisture) and meteorology, providing a new modeling capability for studying land- atmospheric dust interactions.

Another component of this project is the development of the Asian Dust Databank by integrating the diverse satellite and ground-based data on land-use/land-cover, atmospheric mineral dust, and climatic variables in Central and East Asia. Establishing an observation-based climatology of dust storm events is one of the key goals of this effort. Figure 1 shows the analysis of WMO dust present weather frequency from 1950 to 2006, revealing complex patters of spatial and temporal distributions of dust outbreaks. The newly developed WRF-DuMo regional modeling system in conjunction with the Asian Dust Databank is being used to study the effect of dust and LCLUC on climate of drylands in the NEESPI study domain.

Recent Publication: Darmenova, K., and Sokolik, I.N. (2007). Assessing uncertainties in dust emission in the Aral Sea region caused by meteorological fields predicted with a mesoscale model. Global and Planetary Change, 56, 297-310.
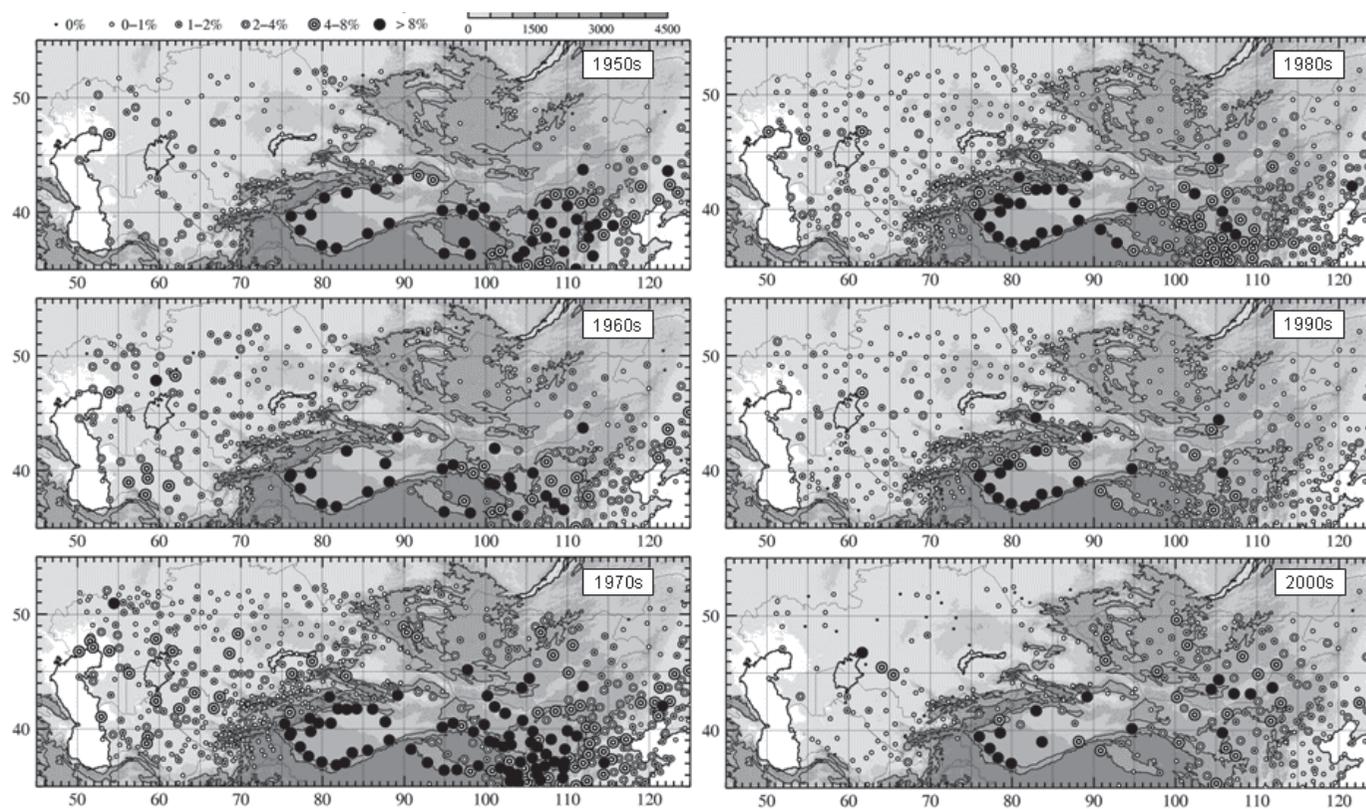
Spatial and temporal changes of dust storms in Central and East Asia shown in terms of decadal frequencies of WMO dust present weather.

Sample Project: Wildfire, ecosystems, and climate: Examining the relationships between weather, extreme fire events and fire-induced land-cover change in the changing climate of Siberia

Amber J. Soja (PI), NIA, NASA LaRC, Nadezda Tchebakova, Elena Parfenova, Anatoly I. Sukhinin, Galina A. Ivanova, Sukachev Institute, Paul W. Stackhouse Jr. NASA LaRC, and David J. Westberg, SSAI

This research is focused on elucidating the factors that force the dominant driver of Land Cover Change (LCC) in Siberia, fire, which is shaped by human and climate dynamics. It is predicted warming in Northern Eurasia will exceed 40% of the global mean. Our investigation found January temperatures in the south central Siberian Sayani mountain range have already exceeded 2090 Atmosphere Ocean General Circulation Model predictions. Additionally, we concluded that 7 of the last 9 years have resulted in extreme fire seasons, which implies the definition of a "normal" fire year may already be changing. We contend that fire, under the influence of weather, climate and human management, is a mechanism to maintain vegetation stability and diversity in equilibrium with the climate and also a mechanism by which land cover moves more quickly towards a new equilibrium with changing climate. Our research demonstrates the affects of fire and weather are regional and particularly evident in ecotones at upland and lowland treelines of mountainous regions and at the far southern and northern reaches of Siberia. The strong influence of fire weather in Sakha (northern Siberia) is pictured in figure 1, which is information that can be used to predict future vegetation change, driven by fire, weather and climate (figure 2). In Tuva (southern Siberia), we highlight the disappearance of the relic Pinus sylvestris forests, which are first burned and then lack weather conditions conducive for germination and survival. Notably, we found there is already substantial evidence of warming- and fire-induced LCC across Northern Eurasia, which suggests a potential non-linear rapid response to climate change, as opposed to the predicted slow linear response to climate change.
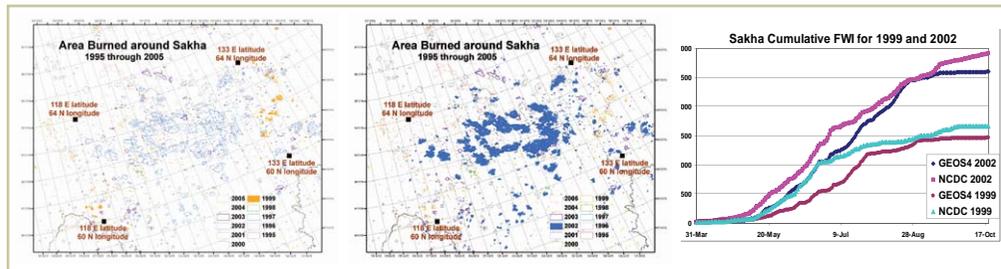

Figure 1. Area burned (AB) and Fire Weather Indices (FWI) demonstrate the influence of weather on fire. AB shown from a normal fire year, 1999 (1A), and an extreme fire year, 2002 (1B), in Sakha. Cumulative FWI are calculated using: station (NCDC), and larger-scale reanalysis (GEOS4) data, which offers spatial and temporal consistency. Specifically, in comparison with 1999, 2002 had 51% more days with temperatures ≥ 20oC, 46% more days with wind speeds ≥ 20 km/hr, 65% more days with relative humilities ≤ 30%, and twice as many days with precipitation ≤ 5mm.
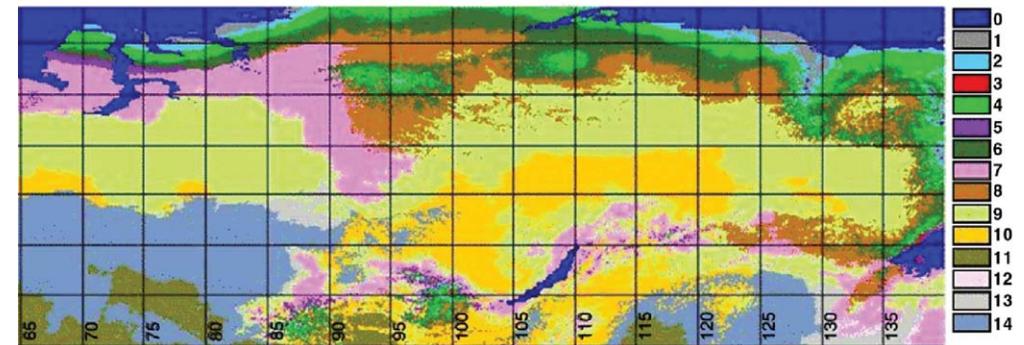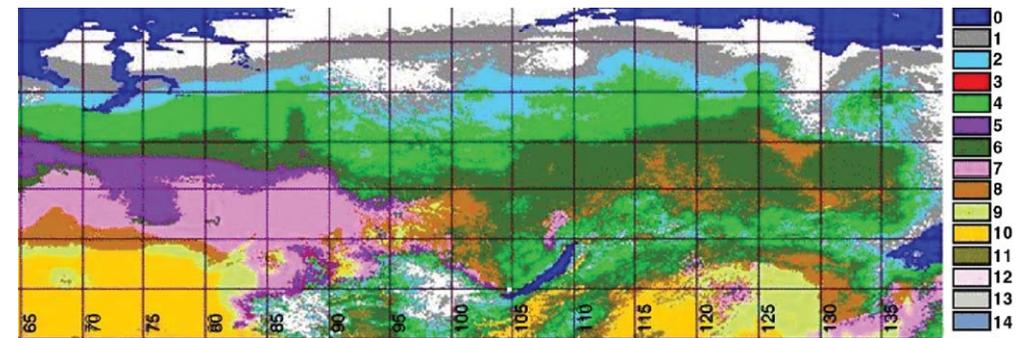
Figure 2: Vegetation distribution in Siberia: (A) current and (B) future (2100) based on a Hadley scenario (HadCM3GGaI) (IPCC,1996). Water (0), tundra (1), forest–tundra (2), northern dark taiga (3) and light taiga (4), middle dark taiga (5) and light taiga (6), southern dark taiga (7) and light taiga (8), forest–steppe (9), steppe (10), semi-desert (11), broadleaved (12), temperate forest steppe (13) and temperate steppe (14)

Recent Publication: Soja, A.J., N.M. Tchebakova, N.H.F. French, M.D. Flannigan, H.H. Shugart, B.J. Stocks, A.I. Sukhinin, E.I. Parfenova, F.S. Chapin III, and P.W. Stackhouse Jr. (2007). Climate-induced boreal forest change: Predictions versus current observations, *Global and Planetary Change, Special NEESPI Issue, 56,* (3-4).

Sample Project: Interactive effects of conservation and development policies on land cover and panda habitat in the Sichuan Giant Panda Sanctuary, China

Jianguo (Jack) Liu, (PI), Michigan State University, Andrés Viña, Michigan State University, Zai Liang, State University of New York, Zhiyun Ouyang, Chinese Academy of Sciences, and Sandra Batie, Michigan State University

Government policies shape human activities that drive land cover changes and impact wildlife habitats. They can be broadly sorted into two categories: development policies and conservation policies. Development policies aim to improve human well-being, while conservation policies aim to protect and restore natural ecosystems. This team of researchers is investigating the interactive effects of the concurrent implementation of two conservation policies (National Forest Conservation Program and Grain-to-Green Program) and a development policy (West China Development Program) on land cover and panda habitat dynamics across the Sichuan Giant Panda Sanctuary – a recently created World Heritage property of UNESCO. The team is collecting and analyzing past and current data derived from remote sensing, field surveys and interviews with stakeholders. Time series of land cover and panda habitat change observed before (1990-2000) and after (2000-2010) the implementation of the three programs are being generated and compared in order to evaluate dynamics of the spatial extent, rates of change and degree of fragmentation in response to these programs.

Preliminary results show that a reduction in the agricultural population has been observed in many counties of the study area during the last decade, mainly as a result of rural-to-urban migration. Lower panda habitat loss rates are, in general, associated with counties that exhibit higher reductions in agricultural population, suggesting a decrease in the pressures of humans on panda habitat as a result of shifts from agriculture to non-agriculture economies. Results like these will be integrated into a spatially explicit model that simulates the outcome of different scenarios induced by the differential implementation of conservation and development programs on land cover and panda habitat dynamics. The model constitutes a useful tool to ask "what-if" questions and visually view the spatial patterns and temporal dynamics of land cover and panda habitat changes under different scenarios of policy implementation. The research will have important implications for widening the application of the land change science to sustainable management of natural resources.
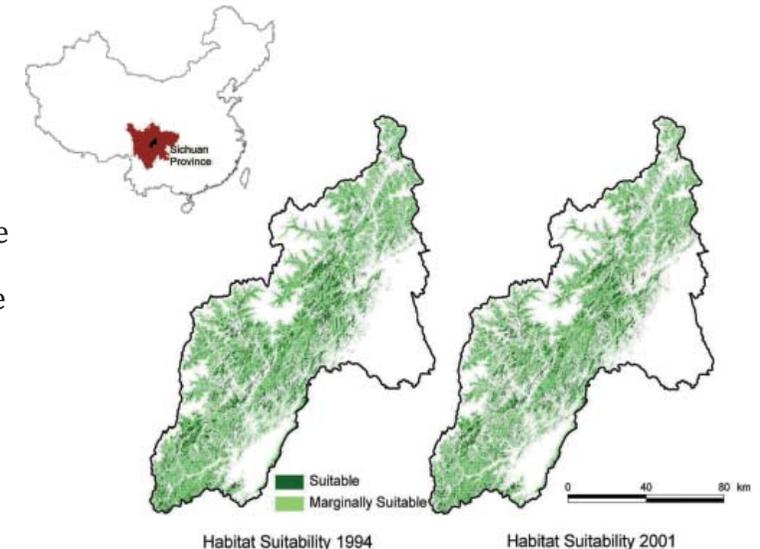
Giant panda habitat suitability in the Qionglai Mountain range, Sichuan Province, China.
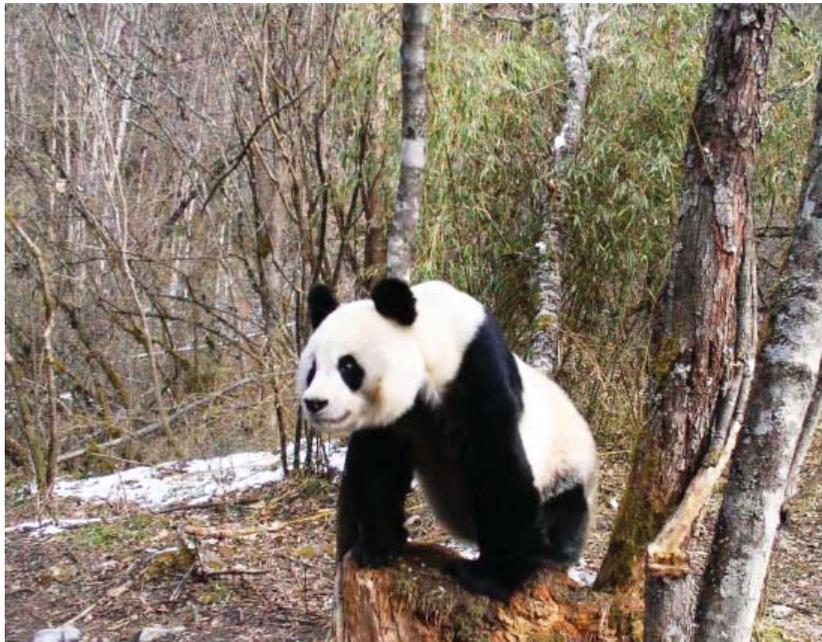
Adult female giant panda in Wolong Nature Reserve (China), 31 December 2006. Photo credit Wei Liu.

National and International Partnerships

At the national level interagency cooperation is organized through the Land Use Interagency Working Group of the US Climate Change Science Program (http://www.climatescience.gov/) and in this framework a number of recent data initiatives have been developed between NASA and the USGS. At the international level there are several program partnerships. LCLUC is an active partner with:

The Global Observation of Forest Cover-Global Observation of Landcover Dynamics (GOFC-GOLD) Program

http://www.fao.org/gtos/gofc-gold/ has a number of coordination initiatives underway including the Reducing Greenhouse Gas Emissions from Deforestation and Degradation (REDD) in developing countries sourcebook and has developed regional networks of scientists involved in land cover and land use research. Through GOFC-GOLD, LCLUC is contributing to a number of land-related tasks of the Group on Earth Observation (GEO). http://www.earthobservations.org/

The Committee on Earth Observation Satellites (CEOS) Land Product Validation Working Group

http://lpvs.gsfc.nasa.gov/ is working to establish international standards and protocols for geophysical product validation, including land cover and burned area.

The Global Land Project (GLP)

http://www.globallandproject.org/ a joint project of IGBP and IHDP, the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) http://ileaps.org/ and with the global change System for Analysis Research and Training (START) http://www.start.org/, which fosters regional collaboration with developing country scientists.

Current Regional Collaborations

Linkages are also made to number of regional initiatives which are addressing aspects of land-cover and land-use research. These initiatives provide a wealth of local expertise in regional land use science. Given the local nature of land use change, local knowledge is essential in understanding the processes and interpreting satellite data and model output. LCLUC scientists working on international projects are strongly encouraged to develop regional collaborations.

GOFC-GOLD and UN-REDD

The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD) is a collaboration between FAO, UNDP and UNEP, aimed at generating the requisite transfer flow of resources to significantly reduce global emissions from deforestation and forest degradation. The goal is to assess whether carefully structured payment structures and capacity support can create the incentives to ensure actual, lasting, achievable, reliable and measurable emission reductions while maintaining and improving the other ecosystem services forests provide. Satellite remote sensing has a role to play in providing transparent monitoring of forest cover change. In this context, the GOFC-GOLD community has developed a REDD sourcebook of methods and procedures for monitoring, measuring, and reporting.

Forest clearing for shifting cultivation, Basankasu, DRC - Photo by Janet Nackoney

http://www.gofc-gold.uni-jena.de/redd/

Monsoon Asia Integrated Regional Study (MAIRS)

http://www.mairs-essp.org/ MAIRS focuses on human monsoon system interaction and seeks to understand to what extent the human activities modulate the Asia monsoon climate and how the changed monsoon climate will impact further the social and economic development of Asia.

Northern Eurasia Earth Science Partnership Initiative (NEESPI)

http://neespi.org/ NEESPI works to develop a comprehensive understanding of the Northern Eurasian terrestrial ecosystem dynamics, biogeochemical cycles, surface energy and water cycles, and human activities and how they interact with and alter the biosphere, atmosphere, and hydrosphere of the Earth.

Large-scale Biosphere-Atmosphere experiment in Amazonia (LBA)

http://www.lbaeco.org/ LBA studies how tropical forest conversion, re-growth and selective logging influence carbon storage, nutrient dynamics, trace gas fluxes and the prospect for sustainable land use in Amazonia. by supporting increased local, national, and regional natural resource management capacity

Central African Regional Program for the Environment (CARPE)

http://carpe.umd.edu/ CARPE aims at promoting sustainable natural resource management in the Congo Basin and works to reduce the rate of forest degradation and loss of biodiversity by supporting increased local, national, and regional natural resource management capacity.

Sample Project: Land use-ecosystem-climate interactions in Monsoon Asia: Evaluating the impacts of current and projected LCLUC on climate, water and carbon cycling in the first half of 21st Century

Hanqin Tian (PI), Auburn University, Robert Dickinson, Georgia Institute of Technology, Jerry Melillo, Marine Biological Laboratory, John Reilly, Massachusetts Institute of Technology, and Hassan Virji, International START Secretariat

Monsoon Asia is a region of Asia that comprises over half the world's population, consisting of 20 countries in South, Southeast and East Asia. This area is controlled by monsoon climate which is of crucial importance to Asia mainly because it brings the water that supports human life, plants and animals. In the past decades, this region has experienced one of the most rapid changes and is likely to undergo further rapid development in the coming years. Land-cover and land-use changes (LCLUC) in Monsoon Asia are being powered by demand for food for its growing population, a large demand for bioenergy for its economic development and by the transition from a largely rural society to one in which more than half of its people are expected to live in cities within two decades. People want to use land for energy, to live and for food, so all are competing for land. There is a rapidly increasing concern that land cover and land use changes are expected to have significant impact on the variability and intensity of the Asian monsoon and further influence the provision of goods and services by terrestrial ecosystems in the region.

The goals of this project are to understand complex interactions among land use, ecosystem and climate and to evaluate the impacts of current and projected LCLUC on climate, water and carbon cycling in the region of Monsoon Asia in the first half of 21st century.

Our strategy to pursue our goals involves the following major objectives: 1) We will develop and use an Integrated Regional Earth System Model (IRESM) that will include an enhanced dynamic land ecosystem model (DLEM), a newly developed regional climate model, an extant economic model, and an improved land use model. 2) We will evaluate and validate IRESM against ground and satellite observations. 3) In support of this

work, we will develop and refine a 30 km gridded dataset for Monsoon Asia by using a combination of ground- and satellite-based observations. This dataset will include information on LCLUC, climate, chemistry of the atmosphere and precipitation, and fires. 4) We will assess regional fluxes of carbon and water across monsoon Asia in the 20th century, and understand the mechanisms that affect these fluxes. 5) We will assess to what extent LCLUC has modulated and will modulate the Asia monsoon climate in the past and future, and how the changed monsoon climate will influence LCLUC in this region in the first half of 21st century. 6) We will propagate and calculate the sensitivities of the IRESM to major inputs and model parameters, and use those sensitivities to quantify uncertainties in the system results. This research will be done in a fully collaborative fashion with a team of scientists from both US institutions and Asian countries in the region. Together, we will develop the input databases, conduct model simulations, and evaluate the results. Our preliminary analysis indicates that there has been a dramatic land transformation across the region in the past 300 years. Cropland and urban areas increased by 288% and 243% respectively, while forest and grassland areas decreased by 23% and 10% respectively.

As estimated by the dynamic land ecosystem model (DLEM), LCLUC has resulted in a large amount of carbon release from terrestrial ecosystems to the atmosphere (See figure) and led to a large reduction of water yield over the region during 1700- 2005. Our

simulated results indicate that LCLUC-induced changes in both carbon storage and water yield show substantial spatial variation across the region. Most of these changes have occurred since the beginning of the 20th century.

Recent Publication: Tian, HQ. X. Xu, C. Zhang, W. Ren, G. Chen, M. Liu, D. Lu and S. Pan. (2008) Forecasting and Assessing the Large-scale and Long-term Impacts of Global Environmental Change on Terrestrial Ecosystems in the United States and China. In: S. Miao, S. Carstenn, and M. Nungesser (Eds), Real World Ecology: large-scale and long-term case studies and methods. Springer-Verlag, New York.
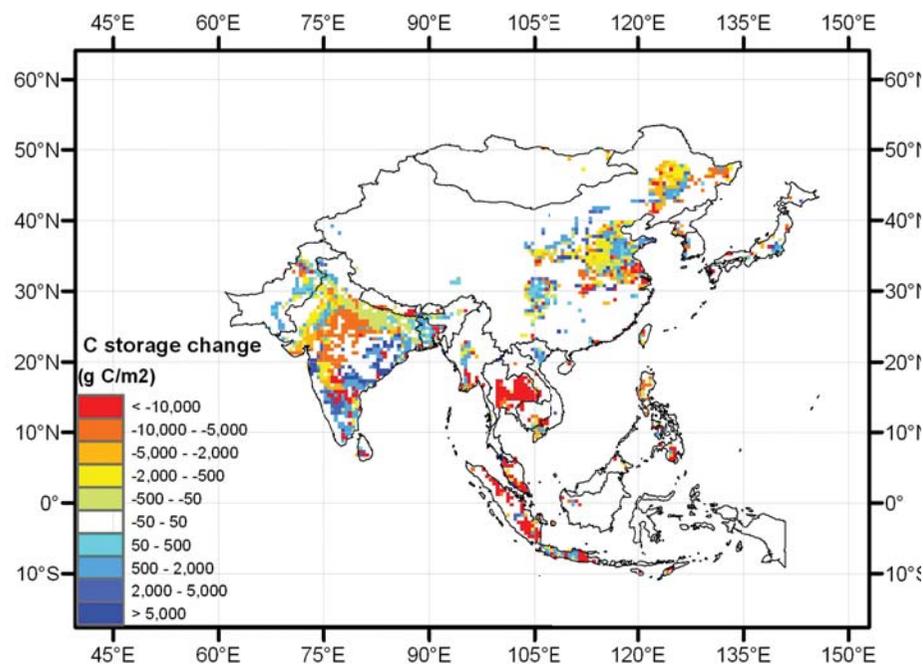
Changes in carbon storage in the terrestrial ecosystems of monsoon Asia induced by land-cover and land-use change during 1700-2005 as simulated by the Dynamic Land Ecosystem Model (DLEM).

Sample Project: Monitoring and modeling urbanization in China: A mixed methods and multi-scale approach

Annemarie Schneider (PI), University of Wisconsin, Madison, Kurt Paulsen, University of Wisconsin, Madison, Karen C. Seto, Yale University, and Jianfa Shen, Chinese University of Hong Kong
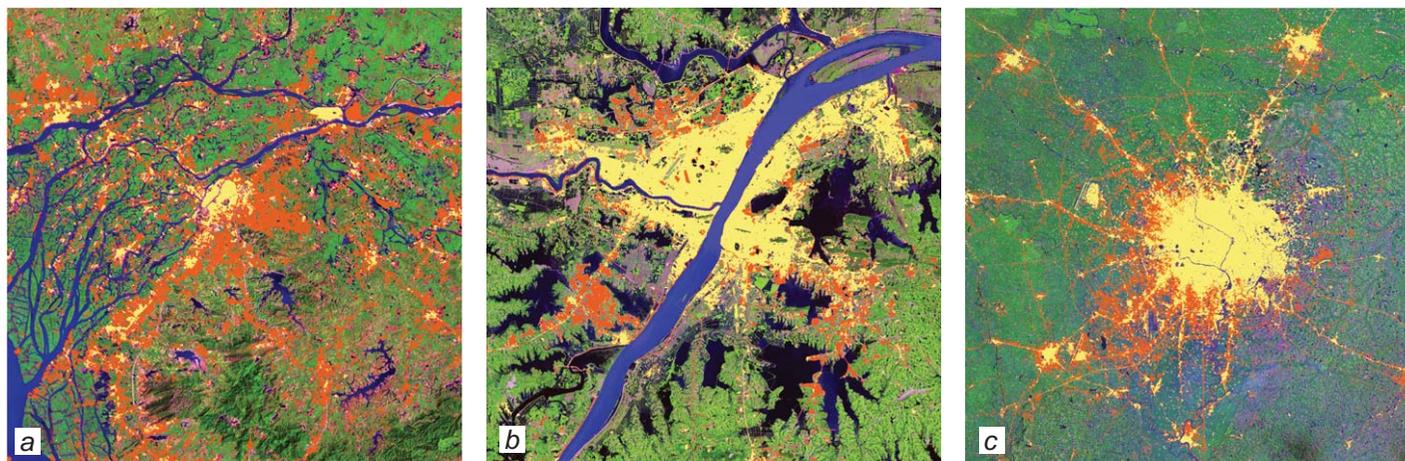
Figure 1: Three views of rapid urban expansion in China developed using multi-date time series of Landsat imagery and multi-temporal change detection techniques. Coastal cities such as Dongguan (a) have developed at an unprecedented rate, spurred by high rates of both foreign and domestic investment in the post-reform period. The Go West program, initiated in the 1990s to address growing regional inequality, extended reforms to cities such as Wuhan (b) and Chengdu (c) in central and western China. In Chengdu, for example, this program has created opportunities for joint venture industry, and the city has rushed to build modern-looking business districts outside the city and erase Mao-ist era housing. This type of expansion has only further heightened the demand for cars, thereby increasing the demand for new roads and a cheap energy supply.

veloping accurate simulations of future land conversion and urban sprawl. Our final objective for this project is develop simulations that explore how urban areas will respond to scenarios such as business-as-usual, increased economic growth and policy-based stimulus. We will project levels of urbanization at the county level for each of our 15 sample cities from 2010 to 2040 (five-year intervals). These forecasts can help improve our understanding of the dynamics of land use transformations, the relative importance of the drivers that foster/impede land conversion, and the complex interactions between urban change and sustainable systems.

This project aims to improve our understanding of China's extraordinary social, economic and environmental transformation and its impact on land cover change in urban areas across the country. Given the size and scale of China's urban development - urban populations have more than doubled during the last 30 years, and more than 70% of economic activity in now located in cities - we need to monitor urban expansion and provide projections of its influence into the future. Currently, we are using Landsat data as input to advanced data mining algorithms to derive new, spatially explicit datasets of the rates and patterns of land cover change in 15 cities located across China (Figure 1). We will integrate these satellite-based measures of urban expansion with detailed socioeconomic data and policy variables in two econometric models (spatial and aspatial) to quantify the factors responsible for variations in the rates, amounts and patterns of urban expansion across China. Determining the relative impact of drivers such as rural-urban migration, rising incomes, infrastructure investment, and local land management and policy on urbanization is a critical first step to de-

Figure 2: Successful modeling of urban dynamics relies on integrating survey data and field observations into both the remote sensing-based analysis and the statistical models of land cover change (photo by K. Seto).

Recent Publication: Schneider, A. and Woodcock, C.E. (2007, March). Compact, Dispersed, Fragmented, Extensive? A Comparison of Urban Growth in Twenty-five Global Cities using Remotely Sensed Data, Pattern Metrics and Census Information. *Urban Studies, 45*:2, 659–692.

Sample Project: Land cover land use change effects on surface water quality: Integrated MODIS and SeaWiFS assessment of the Dnieper and Don River basins and their reservoirs

Anatoly A. Gitelson (PI), University of Nebraska-Lincoln, Geoffrey M. Henebry (Co-PI), South Dakota State University, Sergey Berdnikov, Southern Scientific Centre of the Russian Academy of Sciences and Feodor Surkov, Southern Federal University, Rostov-on-Don

The collapse of the Soviet Union in the early 1990s and the years of turbulent socio-economic transition during the rest of the decade is now recognized as one of the largest and most rapid LCLUC events of the 20th century. The principal mechanism of LCLUC was the disintegration of the institutions of centralized control over the agricultural sector, without which the agricultural sector contracted sharply throughout the region.

Changes in surface water quality in the wake of the collapse have been documented across Europe. This project focuses on two interrelated questions: (1) What are the significant, observable linkages between LCLUC and reservoir water quality? (2) Can reservoir water quality be effectively monitored using SeaWiFS and MODIS standard data products and new value-added products? We are evaluating the applicability of an inversion technique we developed to retrieve chlorophyll-a concentrations using reflectance spectra from turbid productive waters. We are testing these algorithms using MODIS and SeaWiFS data to monitor chlorophyll and total suspended matter concentrations in large reservoirs in Dnieper and Don River basins and in Azov Sea (Figure 1). We are also evaluating the trends in land surface vegetation. Image time series from MODIS reveal substantial regional heterogeneity in vegetation trends from 2000-2007 (Figure 2).
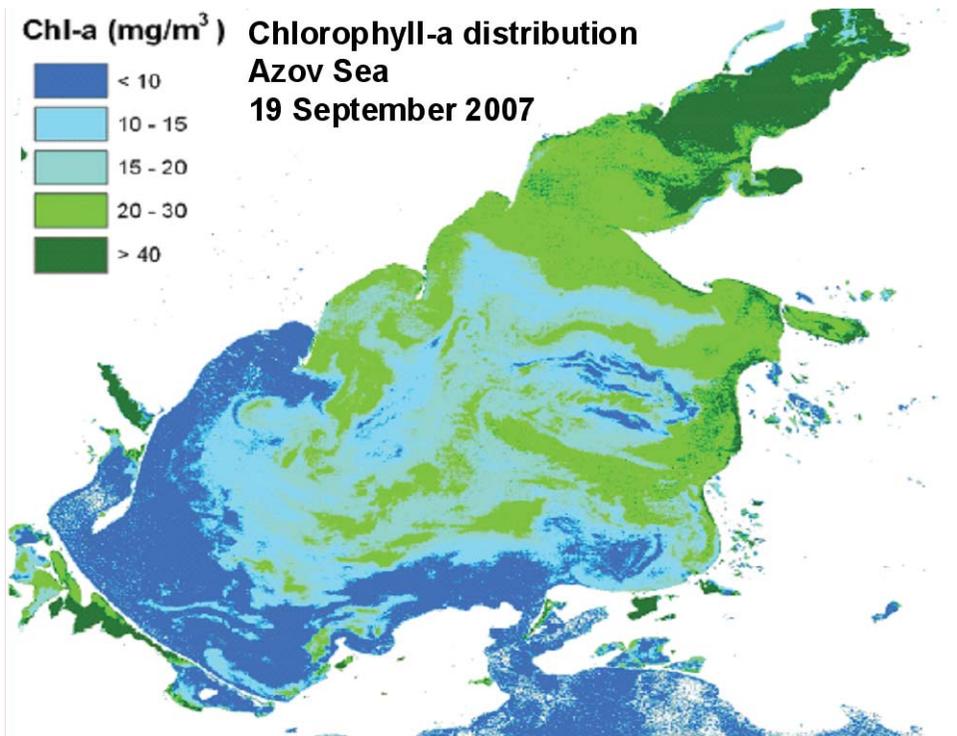
Figure 1 Chlorophyll-a distribution in Azov Sea retrieved from MODIS image using developed model.
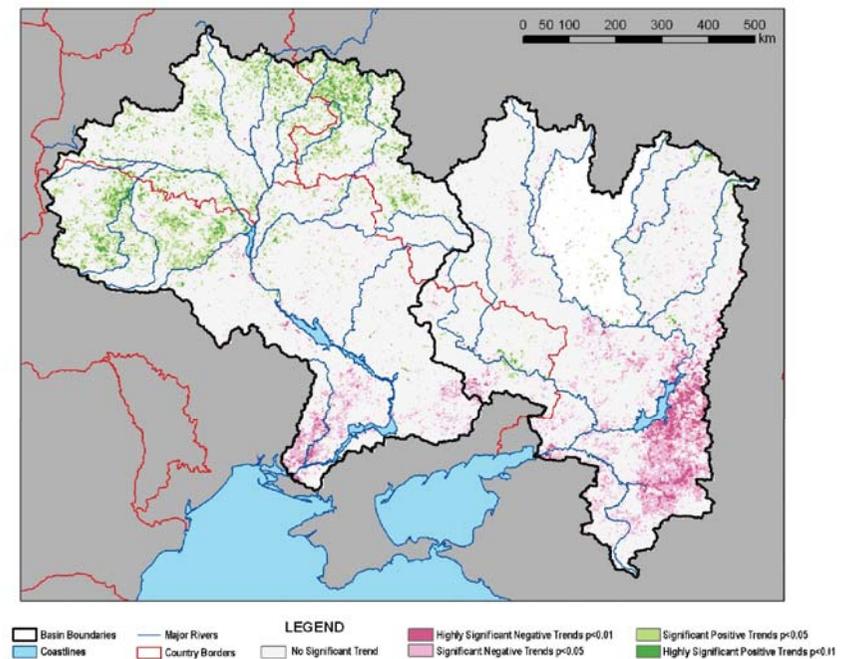

Figure 2 Vegetation trends since 2000 in the Dnieper and Don River Basins: green (magenta) indicates significant increasing (decreasing) trends.

Sample Project: Effects of land-use change (LUC) on the energy and water balance of the semi-arid region of Inner Mongolia, China

Jiquan Chen (PI), University of Toledo, B. Wilske, N. Lu, R. John, A. Noormets, S. McNulty, G. Sun, G. Lin, Y. Wang, K. Guo, J. Ni, X. Han, O. Sun, L.Li, X. Xiao, J. Qi, D. Ojima, S. Denning

Within the NEESPI region, this study focuses on the reciprocal effects of the changes in land use and the energy/water balance in Inner Mongolia where steppe-dominated ecosystems are rapidly transformed into pastureland, agricultural fields, and urbanized areas. As a consequence, severe and frequent catastrophes (e.g., dust storms) have been increasing in recent decades. We combine remote sensing products, modeling, and ground-intensive measurements of climate, carbon and water fluxes through multiple eddy covariance towers, vegetation, and soil in order to understand how LCLUC affects the region.
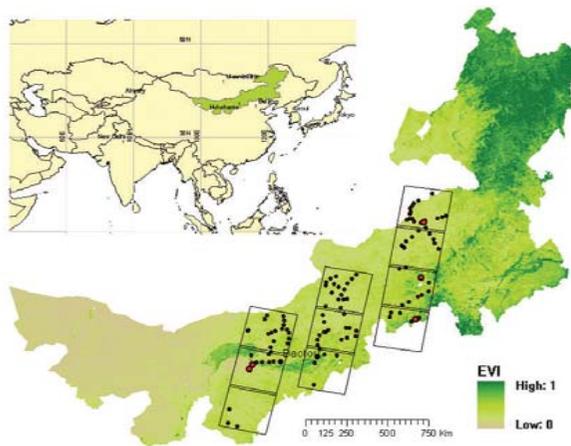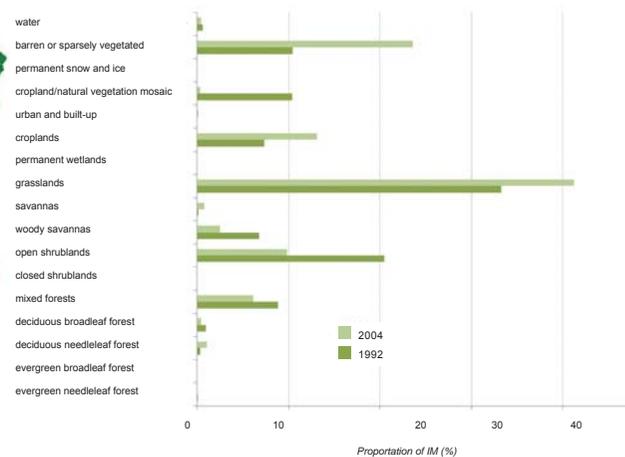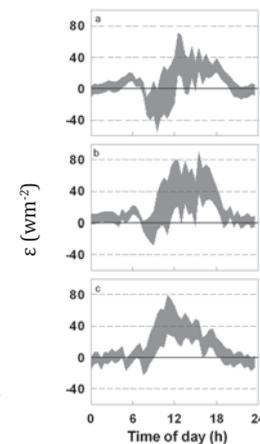
Figure 1

Figure 2

Figure 3

Figure 1. Enhanced vegetation index (EVI) in Inner Mongolia and locations of ground measurements.

Figure 2. Land cover change from 1992 and 2004 in Inner Mongolia in the southern NEESPI region.

Figure 3. Spatial variability of Rn and soil heat flux (G+S) contribute to energy closure at steppe sites in IM: Upper and lower bound of the gray band represent [Rnmax–(G=S)min] and [Rnmin–(G=S)max], respectively.

Major lessons learned so far include:

- The spatial distributions of water and production (MODIS) were closely related to plant species diversity at local and regional scales.
- Significant increases in the air temperature since 1952 have been observed, with the increases varying significantly and being nonparallel among ecosystems.
- Counties dominated by cropland have exhibited greater water use than those dominated by grassland. The annual change in the land surface water index
- (LSWI) was also significantly greater for districts with dry-land irrigated agriculture. Soil moisture from AMSR-E is dependent on the LULC type, with soil moisture increases with vegetation cover.
- Both cultivation and extensive grazing of grasslands had caused changes in canopy surface conductance, soil water holding capacity and soil moisture, which, in turn, decreased the growing season evapotranspiration (ET) by 7-15%.
- Seasonal changes in net radiation, latent heat, sensible heat, and soil heat remained similar at cultivated, overgrazed and natural steppe ecosystems, however, large decreases in stomatal conductance (gc) occurred under intensified land use and consequently reduced ET. The reductions in gc, ET, and the decoupling factor suggest an increased sensitivity to drought.
- Large-scale poplar plantations had significantly increased ET, which would deplete groundwater levels and increase drought stress in the area.

The team is making a significant effort to move the study forward by including feedback between natural and human systems under the changing climate.

Sample Project: Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability of the Eurasian semi-arid grain belt

Geoffrey M. Henebry (PI), South Dakota State University, William Capehart, South Dakota School of Mines and Technology, Elena Lioubimtseva, Grand Valley State University, Kirsten de Beurs, Virginia Polytechnic Institute and State University, Alexander Zolotokrylin, Institute of Geography, Russian Academy of Sciences, Russia, Lev Spivak, Remote Sensing Center, Space Research Institute, Kazakhstan.

The 20th century witnessed some of the most extensive and abrupt LCLUC events in human history. In the mid-1950s, Khrushchev's Virgin Lands Program rapidly expanded the intensive cultivation of grains across the Eurasian steppes. The collapse of the Soviet Union in the early 1990s is now recognized as another widespread LCLUC event.

The principal mechanism of LCLUC across this region was the disintegration of the institutions of centralized control over the agricultural sector. Without these controls and subsidies the agricultural sector contracted sharply during the 1990s throughout the Former Soviet Union and its client states.

There were significant consequent changes in biogeophysical processes, including the onset and timing of land surface phenology (LSP) that links
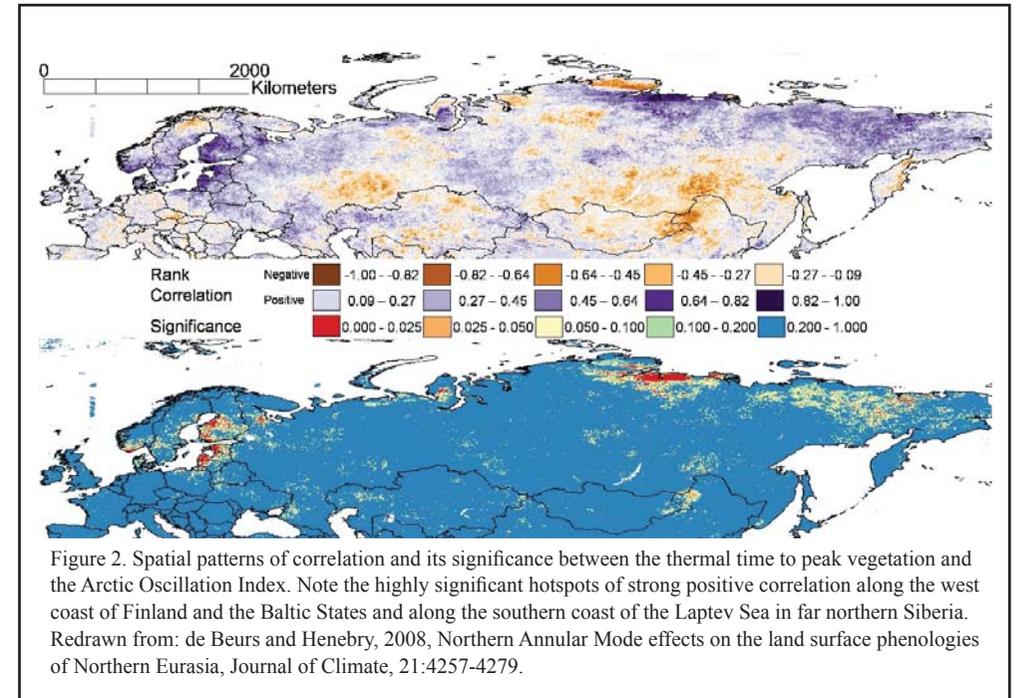

Figure 2. Spatial patterns of correlation and its significance between the thermal time to peak vegetation and the Arctic Oscillation Index. Note the highly significant hotspots of strong positive correlation along the west coast of Finland and the Baltic States and along the southern coast of the Laptev Sea in far northern Siberia. Redrawn from: de Beurs and Henebry, 2008, Northern Annular Mode effects on the land surface phenologies of Northern Eurasia, Journal of Climate, 21:4257-4279.

Figure 1. Trend analysis from MODIS NDVI Collection 5. In this false color composite, the green band displays the average NDVI from 2000-2007 with a threshold of 0.1, the red band displays negative trend statistics, and the blue band displays areas with highly significant (p<0.01) trends. Thus, pink/magenta areas are highly significant negative trends, blue indicate highly significant negative trends, the study area is outlined in white, and coastlines are outlined in yellow.

the ecological dynamics of the vegetated surface with the atmospheric dynamics of the boundary layer.

Using the NASA MODIS products to detect trends in LSP from 2000 to 2007, we find a large expanse of highly significant negative trends located along the southern tier of the study area (Figure 1) with isolated patches of highly significant positive trends in the arid lands of Kazakhstan, Uzbekistan, and Turkmenistan.

Recent Publication: de Beurs, K.M., and G.M. Henebry. (2008). Northern Annular Mode effects on the land surface phenologies of Northern Eurasia. *Journal of Climate, 25*, 4257-4279.
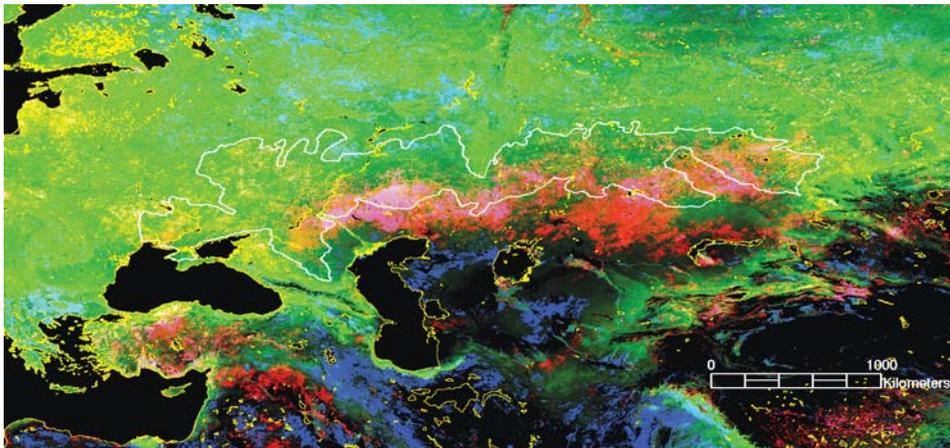
The Large -Scale Biosphere-Atmosphere experiment in Amazonia (LBA)

Sample Project: Spatially specific land cover econometrics and integration with climate prediction: Scenarios of future landscapes and land-climate interactions. *Robert Walker (PI), Michigan State University, Eustáquio Reis, IPEN, Rio de Janeiro, Alex Pfaff, Duke University,), Eugenio Arima (Hobart and William Smith Colleges), Juan Robalino (CATIE, Costa Rica), Claudio Bohrer (Federal University Fluminense), and Marcellus Caldas (Kansas State University).*


Spatial distribution of average annual differences in rainfall (BAU-ROD) for all years and all cases (percentage change at the 95% confidence interval). Also shown are major roads (orange), states (pink, capitalized), rivers (grey) and selected cities (purple).

This project is advancing our ability to anticipate the sustainability impacts of development in the Amazon Basin. Building on past and ongoing LBA efforts, it is extending basin-scale empirical modeling of deforestation at the pixel-level, and integrating predicted land cover changes with a regional climate model to ascertain climate impacts associated with development scenarios for the Amazon Basin. The pixel-level land cover model uses remote sensing products of deforestation to probabilistically describe Amazonian landscapes as a function of the spatial distribution and times paths of observed deforestation drivers. These landscapes, in turn, are input to the regional climate model (the Regional Atmospheric Modeling System [RAMS]). First, the land cover change model produces a set of deforestation probabilities, associated with the specific development scenarios, covering the entire basin. Each pixel, with scenario-specific probability, is treated as a Bernoulli trial, and probability functions of GIS software produce hundreds of realizations of the basin landscape for each scenario. The multiple probabilistic landscapes are input to RAMS, which is executed to produce probability density functions of key variables (e.g., total yearly rainfall), with associated estimates of distributional parameters such as mean value (μ) and variance ($\sigma2$). This explicitly addresses uncertainty by developing measures of central tendency (μ) and dispersion ($\sigma2$) for the estimated climate impacts of the development scenarios. The figure shows spatially-explicit output describing differences at basin scale in rainfall associate with business as usual and restraints on development scenarios. The project is also developing models of forest fragmentation with a Brazilian institutional collaborator, IMAZON. This activity uses maps of logging roads developed by analysis of remotely sensed images, and digital elevation maps based on the shuttle radar topography mission (SRTM). The goal is to refine spatially explicit models of human behavior, in order to accurately reflect processes of forest fragmentation in Amazônia.
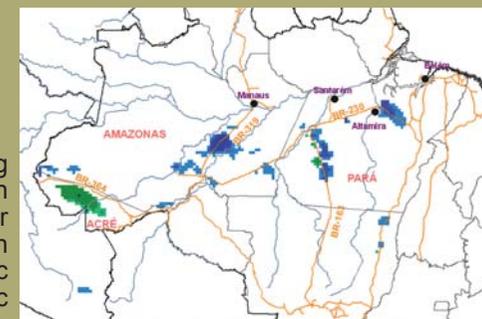
Recent Publication: Arima, E.Y., Walker, R.T., Sales, M., Souza, C. Jr, and Perz, S.G. (2008). Emergent Road Networks and the Fragmentation of Space in the Amazon Basin. *Photogrammetric Engineering and Remote Sensing, 74*(6), 699-709.

Central African Regional Program for the Environment (CARPE)

Sample Project: Producing composite imagery and forest cover and change characterizations for the humid tropics- A contribution to the MDGLS Activity
Matt Hansen (PI), South Dakota State University, Steve Stehman, Tom Loveland, Jim Vogelmann and Mark Cochrane

This project demonstrates a new approach that uses regional/continental MODIS (MODerate Resolution Imaging Spectroradiometer) derived forest cover products to calibrate Landsat data for exhaustive high spatial resolution mapping of forest cover and clearing in the Congo River Basin. The approach employs multi-temporal Landsat acquisitions to account for cloud cover, a primary limiting factor in humid tropical forest mapping. A Basin-wide MODIS 250m Vegetation Continuous Field (VCF) percent tree cover product is used as a regionally consistent reference data set to train Landsat imagery. The approach is automated and greatly shortens mapping time. Derived high spatial resolution forest change estimates indicate that just over one percent of the forests were cleared from 1990 to 2000.
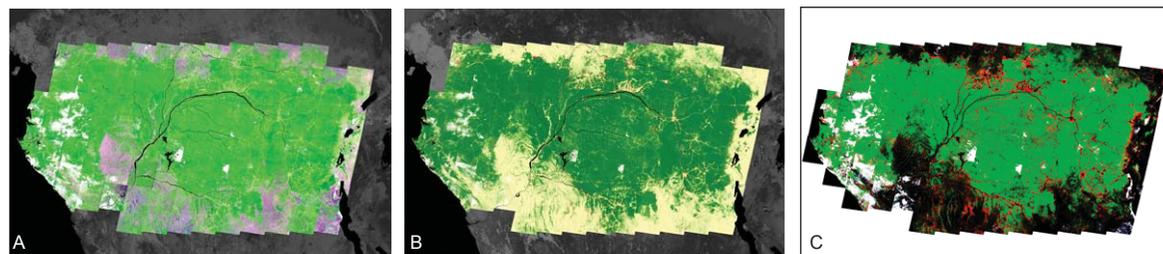
A) example of multi-date composite from circa 2000 epochal Landsat ETM+ imagery with bands 5-4-7 in rgb,
B) full-resolution forest cover and change layer created from 1990 and 2000 regional Landsat composites
C) data from b) aggregated to 1km grid cells to highlight change shown in red.

However, forest clearing is spatially pervasive and fragmented in the landscapes studied to date, with implications for sustaining the region's biodiversity. The forest cover and change data are being used by the Central African Regional Program for the Environment (CARPE) program to study deforestation and biodiversity loss in the Congo Basin forest zone. Data available: http://carpe.umd.edu.

Recent Publication: Hansen, M.C.,Roy, D., Lindquist, E., Justice, C.O., and Altstaat, A. (2008). A method for integrating MODIS and Landsat data for systematic monitoring of forest cover and change in the Congo Basin, *Remote Sensing of Environment, 112,* 2495-2513.

New Investigator Program (NIP)

The New Investigator Program (NIP) in Earth Science was established in 1996 to encourage the integration of Earth system science research and education by scientists and engineers at the early stage of their professional careers. The program, designed for investigators in Earth system science and applications at academic institutions and non-profit organizations, emphasizes the early development of professional careers of these individuals as both researchers and educators. Particular emphasis is placed on the investigators' ability to promote and increase the use of Earth remote sensing through the proposed research and education projects.

The NIP proposals are openly solicited approximately every eighteen months. The awards, to be provided in the form of "education grants," range between $80,000-$120,000 per year for a period of up to three years, subject to satisfactory progress and availability of funds.

Point of Contact:
Dr. Ming-Ying Wei, NASA HQ, Email: ming-ying.wei@hq.nasa.gov

Sample Project: Fire-induced changes in albedo and the associated radiative forcing: A comparison of boreal Canada and Australia tropical savannas

2007 NASA New Investigator Program Scientist: Yufang Jin, University of California, Irvine

This study uses MODIS observations and available fire history data to examine the temporal evolution of post-fire albedo and to derive the associated radiative forcing. This study focuses on two fire-prone regions with very different fire regime and vegetation succession patterns: boreal Canada and northern Australia. I investigate the patterns of post-fire albedo evolution and explain their changes by analysis of vegetation spectral index and structural index derived from MODIS observations. An algorithm is being developed to construct fire chronosequence using fire history data and thus to provide a clearer understanding of albedo evolution through the majority length of vegetation succession stages after fire disturbances. I also investigate the differences among various ecosystems and the impact of the season of burning on vegetation structure and albedo as well as the associated radiative forcing. This study contributes toward a complete and integrated accounting of radiative forcing by albedo change, carbon and aerosol emitted from fire, and thus provides sound scientific knowledge for decisions on carbon/fire management and climate-change policy.
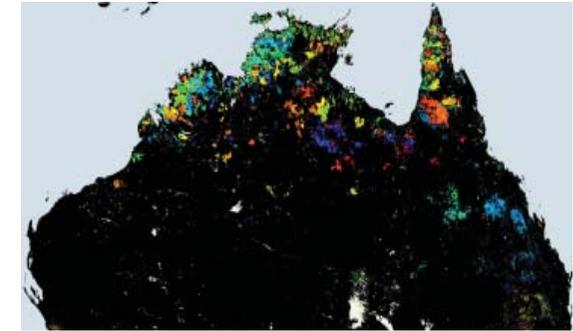

Figure 1. The burned area in 2003 fire season in northern Australia, derived from MODIS time series surface reflectance data. The color represents the date of burning.
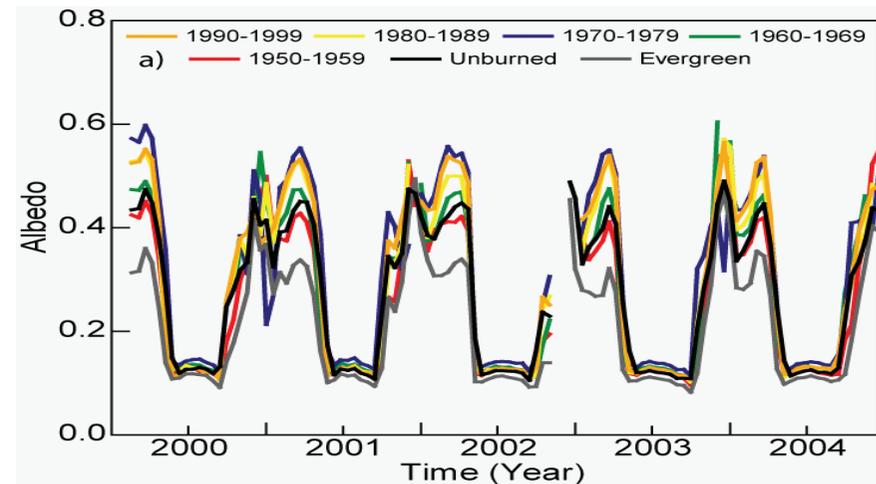

Figure 2. Time series of surface albedo of forests during 2000 – 2004 for different age classes. Areas burned more recently in the 1990s are much brighter in the spring and winter than those burned in the 1950s.

NASA Earth and Space Science Fellowship (NESSF)

The NASA Earth and Space Science Fellowship, formerly known as the NASA Earth System Science Fellowship Program (ESSFP), was started in 1990. The purpose of the program is to ensure continued training of interdisciplinary scientists to support the study of the Earth as a system. Over 800 Ph.D. and M.Sc. fellowships have been awarded since the inception of the program. The graduates from these fellowships constitute a growing network of scholars endeavored to promote Earth system science. In recent years, an increasing number of PhD and Graduate Fellowships have been awarded in the area of land-cover and land-use change research.

Example Project: Impacts of conflict on land cover/land use, fire dynamics, and biodiversity potential in the Imatong Mountains of Southern Sudan
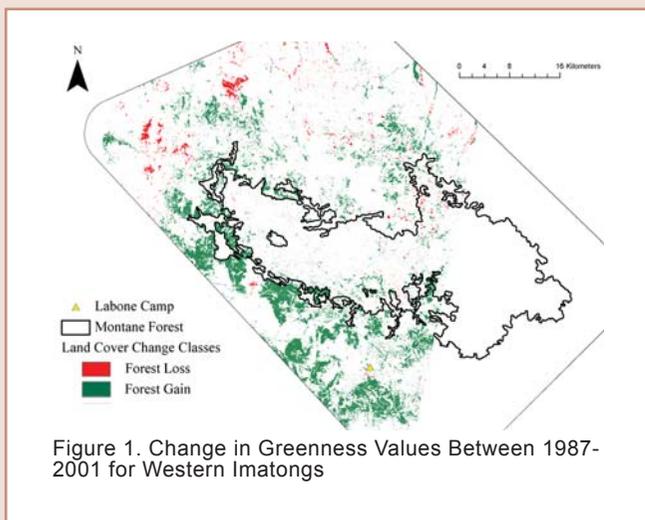
2007 NASA Earth and Space Science Fellowship recipient: Virginia Gorsevski, University of Maryland

Armed conflict negatively impacts ecosystems and wildlife through habitat destruction and fragmentation, direct loss of animals from poaching or land mines, over-exploitation and degradation of natural resources, and land and water pollution. In some cases, however, wars can have a positive impact on natural resources, including wildlife, through the creation of "no go zones" that reduce pressure on the natural landscape due to the absence of exploitative human activity in the area. This project uses satellite data to provide insight into the consequences of conflict and post-conflict population migration on land cover/land use, fire dynamics, and biodiversity. In the Imatong Mountains of southern Sudan, the end of hostilities associated with civil war has caused significant demographic change, resulting in heightened tensions between competing groups as well as increased pressure on the environment. Human encroachment and the frequent use of fire now pose major threats to the long-term ability of the region's ecosystems to simultaneously support local livelihoods and conserve natural resources. For this study, multi-scale remote sensing data will be analyzed with information on human factors within a modeling framework to understand how changes in human population pressure are modifying the local fire regime and land cover. The study will then model the future extent of forest habitat under different scenarios and assess possible impacts on biodiversity in a historically inaccessible and conflict-prone region. Preliminary results indicate using direct change detection techniques indicate that forest accretion has occurred during the conflict period primarily along the southwest perimeter of the montane forest, with the exception of areas around Labone refugee camp and further northwest.

Figure 1. Change in Greenness Values Between 1987-2001 for Western Imatongs

Figure 2. Abandoned tanks in an open field in Juba serve as lasting reminders of the nearly 50 year war between the North and South.

Satellite Remote Sensing

Satellite data provide a means to monitor and characterize land cover and land use change. This is currently undertaken at three scales, global to regional using coarse resolution (1km -250m) data for example from the Moderate Resolution Imaging Spectroradiometer (MODIS), regional to local using moderate resolution (50-10m) data (e.g. Landsat, ASTER, EO1), and locally using fine (<10m) resolution data (e.g. Ikonos, Quickbird). Developing standard atmospherically corrected products and higher order geophysical products such Continuous Fields, Land Cover Change, Leaf Area Index, Fire location and Burned Area removes the processing burden from the science and applications community. These NASA products contribute to the development of the Landcover related Essential Climate Variables (ECV's) identified by the Global Climate Observing System (GCOS). A number of NASA projects have also been supported to improve access to the land data and products. Methods developed by the LCLUC program have enabled regional land cover monitoring using Landsat data. This has been facilitated by the Global Land Survey (GLS), a joint program with USGS, which is providing global, orthorectified Landsat data sets to the research community (GEOCOVER 1990, 2000, 2005). The recent opening up of the entire National Landsat Archive by the USGS will allow for expanded regional, multi-temporal analysis.

Landsat-class instruments provide the basis for much of the LCLUC science. Landsat 7 developed a line-scan problem in 2003 and there is a pressing need to launch the follow-on Landsat Data Continuity Mission (LDCM aka Landsat 8). However the LDCM will launch no earlier than December 2011, which could result in an extended data gap. Equally disturbing, is that lack of any plan or funding commitment to launch a Landsat class instrument beyond LDCM. The launch of Landsat-class instruments by India and China/Brazil (i.e. IRS, CBERS), provides an opportunity for a coordinated global constellation initiative on data acquisition and distribution, in the framework of the Global Earth Observing System of Systems (GEOSS) for GLS 2010 and beyond. The high temporal frequency of the Indian AWiFS system provides a new capability for agricultural land use monitoring. Similarly the increase in the coverage of Synthetic Aperture Radar (SAR) data presents new opportunities for LCLUC research. NASA is partnering with the National Oceanic and Atmospheric Administration (NOAA) and the US Department of Defence (DOD) on the development of the Visible/ Infrared Imager Radiometer Suite (VIIRS), which will provide continuity with MODIS. The first of this series of instruments will be launched in 2011 as part of the National Polar-orbiting Operational Environmental Satellite Suite (NPOESS) Preparatory Project (NPP). In addition, NASA is responding to the NRC Decadal Survey, and the Soil Moisture Active Passive (SMAP) and the Deformation Ecosystem Structure and Dynamics of Ice (DESDynI) missions will be of considerable interest to the LCLUC community.

Land Measurement Portal

With the increasing number of satellite systems and land products available, it is difficult for the community to know what is available and how to access the data. The Land Measurement Portal is designed to be a single location to find information about products related to terrestrial observations being developed across agencies and institutions along with links to sources of these data. The portal also serves as a means to promote new products and projects and stay informed about institutional observation and products coordination efforts, news, and meetings relevant to the land measurements community. The figure to the right illustrates the Land Measurement Portal product suite for LCLUC products. The suite provides basic information about products along with links to more information, validation, and sources of data (panel to the right). The suite also presents the user with the ability to define the displayed products by spatial, temporal, regional, and sensor attributes to aid in product discovery.

Land Portal URL: http://landportal.gsfc.nasa.gov

Global Land Survey (GLS) Data Sets

Global monitoring of land-cover change requires a long record of high-quality remote sensing observations. International programs (e.g. GOFC-GOLD) have called for repeated inventories of land cover on 5-year cycles in order to assess trends and short-term ecological changes (e.g. disturbance). In order to meet this need, NASA and the USGS have partnered to produce the Global Land Survey (GLS) data sets. These data consist of orthorectified, substantially cloud-free Landsat images of Earth's land areas centered on 1975, 1990, 2000, and 2005 epochs. In 2008, NASA and USGS are releasing the GLS2005 data set through the USGS data portals, GloVis (http://glovis.usgs.gov) and Earth Explorer (http://earthexplorer.usgs.gov). The GLS2005 data set includes some 9000 Landsat 5 and Landsat 7 images with supplementary EO-1 ALI imagery of small islands and reefs and ASTER imagery where suitable Landsat data were not available. The data set includes coverage of Antarctica through the LIMA project, part of International Polar Year activities. In addition, the earlier GLS (nee Geocover) data sets were reprocessed to improve their geodetic accuracy using additional ground control and SRTM digital elevation data.

Since Landsat 7 ETM+ experienced a failure of the scan-line corrector in 2003, the GLS2005 data set includes a mixture of Landsat 7 and Landsat 5 data. For locations where multiple, cloud-free ETM+ images were acquired during the 2004-2007 period, two or more of these images were composited together to create a "gap filled" product. In other cases, Landsat 5 data were used. Landsat 5 data for GLS2005 was made available through the network of Landsat International Cooperator ground stations. In addition, short-term campaign stations were set up in collaboration with DLR (Germany) and ScanEx (Russia) to acquire Landsat 5 imagery over Central

GLS Website: http://gls.umd.edu

America and Russia. Actual scene selection for GLS2005 was conducted via an automated scene selection package called LASSI (Large Area Scene Selection Interface) that optimizes for multiple conditions including image cloud cover, sensor preference, seasonality, and residual gap fraction. The scenes were then processed and distributed by USGS EROS.

GLS2005 imagery are being used to assess large-area rates of land cover change, both by international programs (GOFC-GOLD, FRA2005) and through NASA-funded LCLUC projects. NASA LCLUC investigations are listed in the table below. The success of the GLS2005, plans are under way for a GLS2010 follow-on. Given the limited capabilities of the current Landsat sensors, the GLS2010 will include an international component organized through the CEOS Land Surface Imaging (LSI) Constellation. It is hoped that the new data set will include participation by other operators of mid-resolution remote sensing missions.

GLS Time Series Images
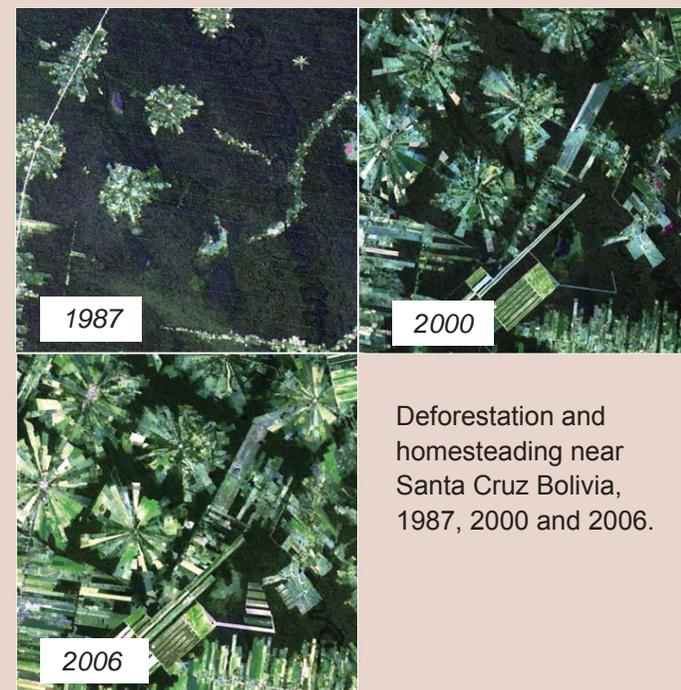
1987 *2000* *2006*

Deforestation and homesteading near Santa Cruz Bolivia, 1987, 2000 and 2006.

PI, INSTITUTION	TOPICAL AREA
Chandra Giri, SAIC/USGS EROS	Tropical mangrove mapping
Matthew Hansen, South Dakota State University	African and boreal forest-cover change
David Skole, Michigan State University	Amazon and SE Asia forest-cover change and disturbance
John Townshend, University of Maryland	Global forest-cover change
Xiangming Xiao, University of Oklahoma	Land-cover change in Monsoon Asia and radar integration
Curtis Woodcock, Boston University	Accuracy assessment of land-cover products
Bruce Davis, NASA Stennis Space Center	Comparison of AWifs & Landsat data
Gyanesh Chander, USGS Earth Resources Observation and Science (EROS)	Cross calibration of US and foreign Landsat class sensors

APPLICATIONS

As the LCLUC program explores aspects of how we use and manage the land, the scientific research findings, data and models produced by LCLUC scientists often have practical applications and societal benefit. Similarly, the satellite systems developed for research can also be put to practical use. The NASA Applied Sciences program conducts a number of land cover and land use related projects with national, regional and international operational partners. These are aimed at transitioning NASA research into the operational domain.
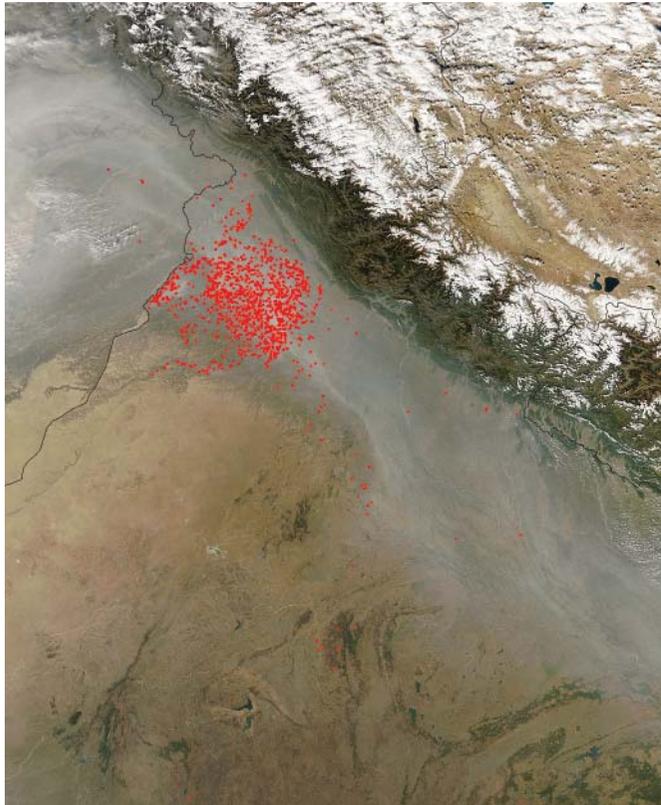
MODIS Rapid Response System image. Fires and smoke in northern India.10/29/ 2008

Global Fire Information for Resource Management System (FIRMS): Transitioning from research to operations

Diane Davies (PI) University of Maryland, Minnie Wong, University of Maryland, Shriram Ilavjahala, University of Maryland.

This project delivers satellite derived fire observations from the MODIS Terra and Aqua satellites to protected area, and natural resource managers, around the world. Specifically, satellite remote sensing and web-GIS technologies are integrated to deliver MODIS active fire data and MODIS images in easy to use formats.

These formats include an open-source web mapping service, the ability to visualize the most recent fires in Google Earth and NASA World Wind, ESRI shape files, text files and customized e-mail alerts that can be delivered in near-real time or as daily or weekly summaries. In the future, FIRMS will incorporate the MODIS burned area product and satellite-derived active fire data from other sensors.

FIRMS is one of many services designed to
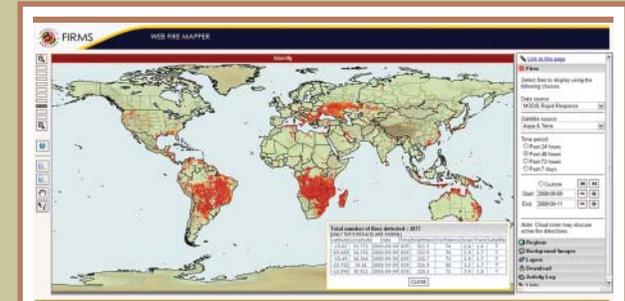
Screenshot of the FIRMS Web Fire Mapper internet mapping service

improve accessibility to satellite derived information. It seeks to overcome some of the obstacles that often prevent the uptake of remotely sensed information by a wider population of users. By understanding user requirements and taking advantage of recent developments in Earth Observation global data processing and near-real time monitoring, FIRMS has expanded the number and range of users that are able to access and utilize satellite-derived fire information.

FIRMS is being transitioned to operational systems at the United Nations (UN) Food and Agriculture Organization, UN Environment Program and Conservation International. For more information go to http://maps.geog.umd.edu/firms

Recent Publication: Davies, D.K., Ilavjahala, S., Wong, M. and Justice, C.O. (in press). Fire Information for Resource Management System:Archiving and Distributing MODIS Active Fire Data. IEEE Transactions on Geoscience and Remote Sensing: Special issue on Data Archiving and Distribution.
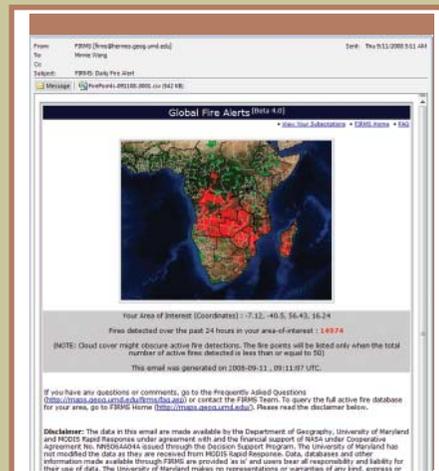
Example of the FIRMS Fire Email Alert for Southern Africa

Giovanni- NEESPI

G. Leptoukh, NASA Goddard Space Flight Center, I. Csiszar, NOAA, P. Romanov, University of Maryland, S. Shen, George Mason University and NASA GSFC, T. Loboda, University of Maryland, I. Gerasimov, RSIS and NASA GSFC.

Giovanni is an acronym for the Goddard Interactive Online Visualization ANd aNalysis Infrastructure. It is a web-based application developed by the NASA Goddard Space Flight Center that provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science data without having to download them. Giovanni-NEESPI is a Giovanni instance that focuses on atmospheric, land surface, and cryospheric products within the boundaries of Northern Eurasia to support the NEESPI project. The current Giovanni-NEESPI version contains both global and NEESPI specific datasets at 1 degree spatial and monthly temporal resolutions organized by three general biospheric components: atmosphere, land surface, and cryosphere. The Giovanni-NEESPI system provides metadata and supporting documentation which describes datasets' structure, parameters, format, spatial extent, fill values, temporal coverage, source data, and reprocessing approach used in aggregating the source data to the 1 degree resolution. The standard HDF file format also allows for including the metadata for each individual parameter/file within the file header.

Project website: http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=neespi
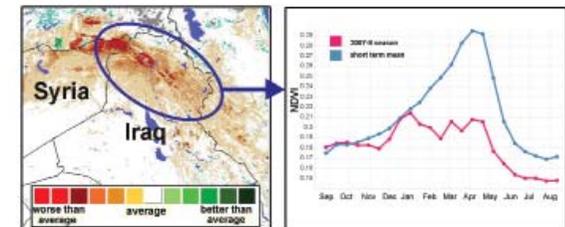
The Global Agriculture Monitoring (GLAM) Project

Christopher Justice (PI) University of Maryland, Mark Sullivan, University of Maryland, Inbal Becker-Reshef, University of Maryland, Assaf Anyanba, University of Maryland Baltimore County, and Compton Tucker, NASA Goddard Space Flight Center

The Global Agriculture Monitoring (GLAM) project is a collaborative project between NASA, University of Maryland and the USDA Foreign Agriculture Service (FAS). The project's objective is to enhance the agricultural monitoring and the crop-production estimation capabilities of the FAS using the new generation of NASA satellite observations. FAS crop analysts use the GLAM web-based information-analysis and data-delivery system, to track the evolution of the growing season by monitoring crop conditions and tracking factors impairing agricultural productivity. To this end, GLAM developed customized web-based information-analysis and data-delivery system to monitor crop conditions and to locate and track the factors impairing agricultural productivity. This system provides crop analysts with a suite of MODIS temporal composites of vegetation index data, false color imagery, and a dynamic crop mask. Complementing these data products is a range of web-based analysis tools that allow analysts to interrogate these data and to drill down to the pixel level of detail. Using these data and tools analysts track the evolution of the growing season, make inter-annual comparisons of season dynamics and inform decision makers of agricultural conditions and impediments to worldwide food-security.

GLAM Project Components:

- Development and delivery of a long term database of MODIS composite Vegetation Index (VI) time series including analysis tools and a graphic user interface that provides mosaicking, reprojection capabilities, and easy access to the moderate resolution image archive.

Tracking severe drought in Iraq and Syria with Vegetation Index Anomalies using GLAM web interface

- Development of a new FAS Near Real Time (NRT) system that provides MODIS 8day and 16day composite Vegetation Index products one day after last composite day.

- Development of enhanced MODIS cropland products including a croplands map and crop type maps

- Delivery and integration of MODIS Rapid Response daily data, available 2 to 4 hours after overpass, into the FAS monitoring system which gives the FAS analysts a unique opportunity to capture sudden phenological changes or to rapidly assess crop damage caused by natural hazards.

GLAM project website: http://www.pecad.fas.usda.gov/glam.cfm

Land-use and land-cover change is now a central interdisciplinary theme of global change research. Understanding how and why we use the land necessitates a human dimension and an integration of both physical and social science. The research agenda has expanded from understanding how changes in land cover contribute to climate and environmental change, to how climate change is impacting land use. As the focus of climate change research expands from causes and attribution to include mitigation and adaptation, land use becomes an increasingly important consideration and the research agenda will expand accordingly.

Land-use practices can contribute to mitigation strategies by carbon sequestration. Climate variability and extreme events are already resulting in land managers adapting how they use the land. Agricultural land-use change research will require increased attention, for example in terms of the trade-off between agriculture for food or energy, the loss of agricultural land by urban expansion, and the impacts on water quality and the coastal zone. Land-use research in the context of carbon management and markets is needed and effective monitoring systems need to be developed. A scientific understanding of the impacts of land-use change and adaptation can provide useful information to land and resource managers at the national, state and local level.

The research agenda requires a better understanding of the causes of land-use change and how land-use decisions are made. Understanding general principles from these processes provides the means for improving predictive models of land-use change and the

International Polar Year: Project EALAT. Photo courtesy of Inger Marie G Eira.

role of land use in integrative assessment modeling and scenario development. The impacts of land-use change play directly into the broader research agenda of sustainability science, for example by understanding the vulnerability or resilience of land-use systems, or approaches to reducing the emissions from deforestation and degradation (REDD).

Underpinning the science is the need for a continuing long-term record of satellite observations to locate and quantify the rates of land-cover change. The recent opening of the USGS archive of 35 years Landsat data for free web-enabled download will

create new opportunities for the study of land-cover change. The partnership with USGS on the upcoming Landsat Data Continuity Mission and the planned NASA Decadal Survey instruments, e.g. DesDyni and SMAP, will open new avenues of research. NASA LCLUC will continue to show leadership in the development of data sets and work with international programs such as GOFC-GOLD and the GEO to coordinate the international observing systems and with the GLP to further the associated scientific research.

List of LCLUC Projects

● **Aizen, Vladimir.** University of Idaho. Estimation of seasonal snow cover and glacial area changes in Central Asia (Tien Shan) during the last 50 years using NASA ESE products and in-situ data

● **Aizen, Vladimir.** University of Idaho. Collaborative research: Diagnosis of changes in alpine water storages and land surface degradation in Pamir Mountains and Amu Dariya River basin

▬ **Bounoua, Lahouari.** NASA Goddard Space Flight Center. Development and validation of process algorithms of urbanization for water cycle, data assimilation and climate studies

▼ **Bowling, Laura.** Purdue University. Multi-sensor/multi-scale assessment of urban impacts in the Great Lakes region

●■ Brown, Daniel. University of Michigan. Changing responses of land dynamics and vulnerability to flooding under policy and environmental change near Poyang Lake, China

▬ **Chander, Gyanesh.** SGT, Inc./USGS EROS Data Center. Cross-calibration of the current Landsat sensors with foreign Landsat-class sensors for long-term monitoring of land surface processes

●■ **Chen, Jiquan.** University of Toledo. Effects of land use change on the energy and water balance of the semi-arid region of Inner Mongolia

▲ **Davidson, Eric.** Woods Hole Research Center. Interactions of edaphic and land use factors on water budgets in Cerrado and semi-arid Caatinga region of Brazil

▬ **Davis, Bruce.** NASA Stennis Space Center. Comparison of AWiFS to Landsat for supplying general LCLUC detection products needed for NASA LCLUC Program science

▼ **Eshleman, Keith.** University of Maryland. Exacerbation of flooding responses due to LCLUC: A comparative study

▼ **Fisher, Thomas.** University of Maryland. Responses of coastal waters to terrestrial inputs of elemental CNP in urbanizing coastal regions

■■ **Fox, Jefferson.** University of Hawaii. The expansion of rubber and its implications for water and carbon dynamics in montane mainland Southeast Asia

▼ **French, Nancy.** Michigan Technological University. Using remote sensing-based measures to assess NRCS impacts in Michigan: Step 2

▬ **Friedl, Mark.** Boston University. Algorithm refinement and Earth Science Data Record development for global land cover dynamics

● **Geerken, Roland.** Yale University. Ecological monitoring in semi-arid Central and West Asia: Drivers and trajectories

▬■ **Giri, Chandra.** USGS EROS Data Center. Tropical mangrove forests: Global distributions and dynamics (1990-2005)

● **Gitelson, Anatoly.** University of Nebraska. LCLUC effects on surface water quality: Integrated MODIS and SeaWiFS assessment of the Dnieper and Don River basins and their reservoirs

▼ **Goetz, Scott.** Woods Hole Research Center. Urban growth impacts on surface hydrology and stream ecology in watersheds of the Mid-Atlantic and New England

● **Goetz, Scott.** Woods Hole Research Center. Quantifying changes in northern high latitude ecosystems and associated feedbacks to the climate system

▼ **Hansen, Andrew.** Montana State University. Vulnerability of US National Parks to land use and climate change and variability: Part 2

▬ **Hansen, Matthew.** South Dakota State University. Establishing a global forest monitoring capability using multi-resolution and multi-temporal remotely sensed data sets

▬♦■ **Hansen, Matthew.** South Dakota State University. Producing composite imagery and forest cover and change characterizations for the humid tropics – A contribution to the MDGLS activity

● **Henebry, Geoffrey.** South Dakota State University. Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability if the Eurasian semi-arid grain belt

SCIENCE THEMES	REGIONS AND INITIATIVES
Detection and Monitoring	■ MAIRS
Water and Energy Cycle	● NEESPI
Predictive Land Use Modeling	▲ LBA
Climate Variability and Change	♦ Carpe
Carbon and Biogeochemical Cycle	▼ North America
Ecosystems and Biodiversity	▬ Global focus

▼ **Hope, Allen.** San Diego State University. Regional hydrologic response of semi-arid Mediterranean climate watersheds to land-cover/land-use variability: Predictive models based on MODIS products

● **Imhoff, Marc.** NASA Goddard Space Flight Center. Global distribution of human appropriation of fresh water: An Earth Observation-supported strategy linking biophysics and socio-economics for addressing water vulnerability

■ **Jain, Atul.** University of Illinois. LCLUC and its effects on carbon dynamics in Monsoon Asian region

— **Justice, Christopher.** University of Maryland. Developing a global burned area ESDR

▼ **Kling, Catherine.** Iowa State University. Interactive drivers of LCLUC in agricultural areas: Climate and land-manager choices

● **Krankina, Olga.** Oregon State University. NELDA: Monitoring and validating the distribution and change in land cover across Northern Eurasia

●● **Lettenmaier, Dennis.** University of Washington. Diagnosis and prognosis of changes in lake and wetland extent on the regional carbon balance of northern Eurasia

●■ **Liu, Jack.** Michigan State University. Interactive effects on conservation and development policies on land cover and panda habitat in the Sichuan Giant Panda Sanctuary (China)

▼ **Liu, Shuguang.** USGS EROS Data Center. Impact of rapid land-use change in the Northern Great Plains: Integrated modeling of land-use patterns, biophysical responses, sustainability, and economic and environmental consequences

■ **Monroe, Darla.** Ohio State University. A comprehensive statistical analysis system to associate local LCLUC and regional aerosol composition and concentration

▲ **Moran, Emilio.** Indiana University. Human and physical dimensions of LCLUC in Amazonia

● **Ozdogan, Mutlu.** University of Wisconsin. LCLUC in temperate forests of European Russia: The past, the current, and the future

■● **Schneider, Annemarie.** University of Wisconsin. Monitoring and modeling urbanization in china: A mixed methods and multi-scale approach

● **Shiklomanov, Alexander.** University of New Hampshire. Northern Eurasian landscapes: Interactions between humans, hydrology, land cover and land use

●■ **Shugart, Hank.** University of Virginia. Evaluation of habitat availability for large carnivores, under a changing climate and disturbance regime: An Amur Tiger and Amur Leopard case study

—◆■ **Skole, David.** Michigan State University. Enhancing global observations and information on tropical forest change using Landsat global data

— **Small, Christopher. Columbia University.** Development and sensitivity analysis of high resolution land surface parameters from satellite data and their use in a meso-scale model - LDEO

● **Soja, Amber.** NASA Langley Research Center. Wildfire, ecosystems, and climate: Examining the relationships between weather, extreme fire events and fire-induced land-cover change in the changing climate of Siberia

● **Sokolik, Irina.** Georgia Institute of Technology. Understanding the role of changes in land-use/land-cover and atmospheric dust loading and their coupling on climate change in the NEESPI study domain drylands

■ **Tian, Hanqin.** Auburn University. Land use-ecosystem-climate interactions in Monsoon Asia

▼▲ **Townshend, John.** University of Maryland. Three decades of forest cover change in the Americas evaluated using the Geocover and MDGLS data sets

▼ **Tucker, Compton.** NASA Goddard Space Flight Center. Identifying and understanding 25 years of North American carbon cycle disturbances

▼ **Turner, Billie Lee II.** Arizona State University. Landscape vulnerability-resilience in the Southern Yucatan Peninsular Region (SYPR)

● **Vorosmarty, Charles.** University of New Hampshire. Role of LCLUC in hydrology of Eurasian Pan-Arctic

▲ **Walker, Robert.** Michigan State University. Spatially specific land cover econometrics and integration with climate prediction: Scenarios of future landscapes and land-climate interactions

● **Walker, Skip.** University of Alaska. Application of space-based technologies to examine LCLUC along a transect on the Yamal Peninsula and Novaya Zemlya, Russia

▲ **Walsh, Stephen.** University of North Carolina. Multi-agent models of LCLUC dynamics in the Northern Ecuadorian Amazon

■ **Xiao, Xiangming.** University of New Hampshire. Developing land cover classification products in Monsoon Asia over the period of 2004-2007 through integration of Landsat and ALOS/PALSAR images

▼ **Zeng, Xubin.** University of Arizona. Relationship between LCLUC and surface hydrology over arid and semi-arid regions

Current NIP Projects

2007 Recipients

Jin, Yufang. University of California, Irvine. Fire-induced Changes in Albedo and the Associated Radiative Forcing: A Comparison of Boreal Canada and Australia Tropical Savannas

Kennedy, Robert. USDA Forest Service. Leveraging Temporal Variation in Climate and Management across National Parks in the Western U.S. to Characterize Three Decades of Landscape Vegetation Dynamics

Lobell, David. Lawrence Livermore National Laboratory. Agricultural Applications of Multi-Year Remote Sensing: A Research and Education Program

Mountrakis, Giorgos. State University of New York. Satellite-Derived Anthropogenic Land Use/Land Cover Changes: Integrating Detection, Modeling and Educational Approaches

2005 Recipients

Manson, Steven. University of Minnesota. American Land Change: Integrated Research and Education on Decision Making in Coupled Human-Environment Systems

Nair, Udaysankar. University of Alabama, Huntsville. Investigation of microclimatic changes associated with tropical forest fragmentation using remote sensing and numerical modeling

Powers, Jennifer. University of Minnesota. A Regional-Scale Analysis of Regenerating Tropical Dry Forests in Costa Rica: Measurements and Models of the Linkages among Biodiversity, Ecosystem Function and Carbon Storage

Song, Conghe. University of North Carolina, Chapel Hill. Impacts of Land-Cover/Land-Use Change on Terrestrial Ecosystem Carbon Budget

NESSF LCLUC Related Projects

2008 Recipients

Barber, Christopher. South Dakota State University. Applied Remote Sensing for Conservation Monitoring

Broadbent, Eben. Carnegie Institution. Influence of Forest Architecture on Carbon Assimilation along an Elevational Gradient in Hawaii: Linking Field Measurements, Airborne LiDAR, and Modelling

Carlson, Kimberly. Yale University. Evaluating and Modeling the Consequences of Oil Palm Expansion in Indonesian Borneo using a Multi-Sensor Satellite Approach

Chow, Victoria. Harvard University. An Integrated Approach to Quantify Regional Carbon Budgets in North America and Amazonia by Assimilation of High-Resolution Meteorological and Remote Sensing Data

Fairman, Jonathan. University of Alabama, Huntsville. Quantifying the Effects of Upwind Land Cover Change on Alpine Glaciers

Foster, Jane. University of Wisconsin, Madison. Forest Insect Defoliation and Carbon Dynamics: Linking Remote Sensing with Simulation Modeling

Longo, Marcos. Harvard University. Interaction between Convection, Disturbance, and Deforestation in the Amazon: A Remote Sensing and Modeling Study

Macedo, Marcia. Columbia University. Tropical Deforestation and the Land-Water Interface: Linking Land Use, Stream Connectivity, and the Health of Freshwater Fish Communities

O'Neal, Kelley. University of Maryland, College Park. Impacts of Grazing, Fire, and Precipitation Variability on Woody Plant Cover in Chihuahuan Desert Grasslands, USA

Santos, Carolina. Michigan State University. Complex Land Use and Cover Trajectories in the Northern Choco Bioregion of Colombia

Serbin, Shawn. University of Wisconsin, Madison. An Integrative Approach for Quantifying the Effects of Disturbance on Regional Forest Carbon Cycling

Tian, Qing. University of Michigan. From Vulnerability to Sustainability: Vulnerability and Sustainable Development in the Context of Climatic and Institutional Changes in Rural China

Tosca, Michael. University of California,

Irvine. Effects of Fire Aerosols on Climate and Drought in Equatorial Southeast Asia

Velasquez, Jorge. Stony Brook University. Using Remote Sensing Products to Predict the Impact of Climate and Land-Cover Change on the Abundance and Distribution of Andean Birds

2007 Recipients

Bolch, Michael. Duke University. Evaluating the Effects of Land-Surface Heterogeneity at Various Scales on Atmospheric Boundary Layer Processes

Dieye, Amadou. South Dakota State University. Land Cover Land Use Change and Soil Organic Carbon under Climate Variability in Semi-Arid to Sub-Humid West African Sahel (1975-2050)

Dubinin, Maxim. University of Wisconsin, Madison. Effects of Land Use Change on Fire, Vegetation and Wildlife Dynamics in Arid Grasslands of Southern Russia

Ellicott, Evan. University of Maryland, College Park. Estimating Global Biomass Burning Emissions Using Fire Radiative Power

Espirito-Santo, Fernando. University of New Hampshire. Natural Forest Disturbance and Carbon Cycling in the Brazilian Amazon: Remote Sensing Approaches at Local and Regional Scales

Gorsevski, Virginia. University of Maryland, College Park. Impacts of Conflict on Land Cover, Fire Dynamics, and Biodiversity Potential in the Imatong Mountains of Southern

Harvest in Idaho, USA. Courtesy of Kelley O'Neal

Sudan

Jiang, Xiaoyan. University of Texas, Austin. Using Satellite Observations and a Fully Coupled Land-Atmosphere-Chemistry Model to Study the Coupling between Vegetation and the Hydrologic Cycle Through Biogenic Emissions Pathways

Kane, Van. University of Washington. Spectral Mixture Analysis of ASTER Images to Estimate Forest Biomass and Habitat

Lindquist, Erik. South Dakota State University. Using MODIS and Landsat Data to Advance Regional, High-Spatial Resolution Change Monitoring for the Humid Tropical Forests of the Congo Basin

2006 Recipients

Adeney, Jennifer. Duke University. Remote Sensing of Essential Drivers of White Sand Systems in the Brazilian Amazon Using Landsat and MODIS

Barnes, Christopher. South Dakota State University. United States Land Cover Land Use Change, Albedo and Radiative Forcing: Past and Potential

Climate Implications

Christman, Zachary. Clark University. Disaggregating Phenological Variation from Discrete Land-Cover Change in the Rio Lerma-Chapala Watershed, Mexico

Dasgupta, Swarvanu. George Mason University. Multi-Sensor Approach for Monitoring Fire Risk in the Wildland Urban Interface

Eckmann, Ted. University of California, Santa Barbara. Validating Retrievals of Subpixel Fire Sizes and Temperatures from MODIS to Improve Understanding and Monitoring of Fires

Galford, Gillian. Brown University. Biogeochemical Consequences of Land-Use Transitions Along Brazil's Agricultural Frontier

Lipscomb, Monica. University of North Carolina, Chapel Hill. Urban Landscape Patterns: Impacts on Hydrologic Processes and Nitrogen Pollution

Loughner, Christopher. University of Maryland, College Park. How Do Changes to the Urban Environment Affect Precipitation and Air Quality?

White, Benjamin. University of Maryland, College Park. Conservation or Degradation: The Impact of Land Cover Change on the "Outstanding Universal Value" of World Heritage Sites