NEESPI/LCLUC Science Team International Regional Meeting on Dryland Processes in Central Asia

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The Northern Eurasian Earth Science Partnership Initiative (NEESPI)/ Land-Cover and Land Use Change (LCLUC) Program Science Team International Regional Meeting on Dryland Processes in Central Asia was held September 16-21, 2007 in Urumqi, China. Xinjiang Institute of Ecology and Geography (XIEG) hosted the meeting. XIEG is an advanced, multidisciplinary institute with a strong focus on ecosystem processes, sustainable development, and resource management in arid lands. Situated in the heart of Central Asia's drylands on the ancient Silk Road, Urumqi was the ideal location for this forum. Over 60 participants joined the meeting representing China, Mongolia, Uzbekistan, Kazakhstan, Tajikistan, Russia, Germany, and the U.S. The objectives of this meeting were to provide an inter-agency and international forum to bring scientists together to discuss drylands research, as well as the importance of data and information sharing. The agenda for this meeting, as well as presentations and posters, can be found on the LCLUC website at: lcluc.hq.nasa.gov.

Science Issues

The focus of the meeting was on global climate change issues relating to and impacting the drylands of Central Asia in particular, with broader application to dryland ecosystems located in other parts of the world. Drylands of Central Asia are *water-limited* ecosystems—i.e., vegetation patterns and ecosystem processes are controlled by water availability. Slight shifts in the water budget can lead to drastic changes in vegetation cover, biodiversity, and ecosystem services in these unique environments. In this manner, drylands are particularly sensitive to the impacts of global climate change and are highly susceptible to substantial, rapid environmental change.

The meeting agenda focused on identifying the data needs for operational monitoring and scientific research, and prioritizing future research objectives in light of the observed and predicted global climate change. Science issues concerning water budgets, water management, soils management, climate change and frequency of extreme events, and Earth system and scale linkages were common themes that ran throughout many of the research presentations. One of the most important science findings highlighted during the meeting is the difference in climate change effects between arid and semi-arid lands in the region. **While semi-arid lands have experienced a decrease in precipitation, arid lands have experienced an increase in precipitation—an unexpected result**. Beyond climate change research, social science issues proved to be the most pressing, with many participants voicing concerns that the social science component necessary for drylands research needs strengthening including local population dynamics, consumption of ecosystem services, agricultural and pastoral systems management, changes in nomadic livelihoods, and inclusion of local stakeholders in scientific research. In addition to data and science needs, speakers emphasized that a key ele-

ment in furthering scientific research and data availability was increased levels of support for international collaboration and regional network-building.

Opening Remarks

Jiyuan Liu [Chinese Academy of Sciences (CAS)], **Chen Xi** [CAS], **Jiaguo Qi** [Michigan State University], and **Hong Li** [CAS] opened the meeting with a warm welcome. They emphasized the importance of research in drylands, in particular those located within Central Asia, throughout the introductions. In addition, they noted challenges of working in the region along with the importance of the meeting in offering opportunity for collaboration and cooperation with other countries, as well as contribution to sustainability science and development research.

Pavel Groisman [NOAA—*NEESPI Program Scientist*] provided an overview of the drylands focus within the NEESPI Program. Groisman placed emphasis on research examining the impacts of climate change, including changes in precipitation patterns leading to prolonged dry episodes. He also stressed the importance of the human dimension, especially as linked to climate change and ecosystem function. Model development—with a focus on feedbacks—and investment in education will both be very important. Looking forward to 2010, he suggested some milestones such as validated, reliable models and increased data support, outreach, and education.

Chris Justice [University of Maryland, College Park (UMCP)—*LCLUC Program Scientist*] provided an overview of the drylands focus within the LCLUC Program. Justice illustrated global distribution and population density within drylands along with reports of climate change impacts in the drylands of Central Asia. In addition, he reviewed LCLUC science themes and program elements and emphasized the six program components. He demonstrated the first component, *regional case studies of land-use change*, showing examples of currently funded regional LCLUC drylands research from case studies around the globe. The second component, *develop and distribute global and regional observations and data sets*, is accomplished through free and open sharing of Earth Observing System (EOS), Landsat *GeoCover*, various Global Land Cover Facility (GLCF), and LCLUC-funded projects datasets. Justice illustrated the third component, *develop conceptual frameworks for LCLUC research*, when he discussed coupled human-environment conceptual frameworks employed in LCLUC-funded sustainability science research and the Global Land Project (GLP). The fourth component, *modeling land-use to understand processes, interactions, and feedbacks*, concentrates on coupled, predictive, and integrated assessment models. The fifth component, *studies providing science underpinning to applications of societal benefit to drylands management*, focuses on water use, shrub encroachment, fire management, livestock management, biodiversity protection, agriculture monitoring, famine early warning, and climate predictions. The sixth component of the LCLUC Program is to *support and promote national and international scientific collaboration through partnerships and linkages*, a goal pursued through venues such as this and future meetings focused on programmatic, scientific, and regional themes.

Garik Gutman [NASA Headquarters—*LCLUC Program Manager*] presented an overview of LCLUC Program linkages to the NEESPI drylands component. Gutman introduced the LCLUC program to attendees who were not members of the Science Team which discussed drivers of disturbance and consequences along with relevant tools (e.g., remote sensing and *in situ* observations, modeling, and data/information systems) for LCLUC studies. He listed NASA and non-NASA systematic and exploratory missions. Gutman outlined LCLUC program contributions to the Global Earth Observation System of Systems (GEOSS) and international projects such as Global Observation of Forest and Land Cover Dynamics (GOFC/GOLD), International Geosphere-Biosphere Programme/ Integrated Land Ecosystem-Atmosphere Processes Study (International Geosphere-Biosphere Programme (IGBP)/iLEAPS), and IGBP-International Human Dimensions Programme (IHDP)/GLP. Further, he described LCLUC support of regional initiatives, putting emphasis on the Monsoon Asia Integrated Regional Study (MAIRS) and NEESPI, explaining the NASA role in these international programs and giving details on the ongoing dryland projects. Gutman stressed the importance for improved programmatic coordination between NEESPI and MAIRS in drylands, and linkages between the LCLUC program and MAIRS in the tropical monsoon region of Asia.

Scientific Presentations

A total of 15 scientific presentations and 16 scientific posters were given during the meeting representing drylands research around the globe. Select presentations and posters have been highlighted.

Chen Xi [CAS] presented an overview of drylands research being conducted at the Xinjiang Institute of Ecology and Geography. The presentation focused on work in Central Asia, with particular emphasis on development and urbanization, land-cover change, desertification processes, sand storms, dune movements, salinization, and water shortages in the region. Xi also emphasized the roles and impacts of human activities on climate and associated regional fluxes in water budget.

Dennis Ojima [H. John Heinz III Center for Science, Economics and the Environment] presented on the effects of climate change and land-use patterns on

pastoral systems throughout Eurasia. Ojima's research focused on nomadic pastoralists in Mongolia and Kazakhstan where socio-economic and lifestyle changes are strongly affecting land productivity and ecosystem sustainability in the region.

Yan Xiaodong [CAS] presented information regarding the role of the iLEAPS project within the IGBP. The objective of the multidisciplinary international research program is to study how interacting physical, chemical, and biological processes transport and transform energy and matter through the land-atmosphere interface.

Lin Zhen [CAS] presented an overview of international collaboration activities and results of research concerning sustainable development of the Mongolian Plateau region. Research focused on climate and land-use change in the region and associated impacts, including accelerated desertification processes, increased soil erosion, a decrease in water availability, loss of livestock, and decreased agricultural yields.

Mutlu Ozdogan [University of Wisconsin, Madison] presented research on the role of remote sensing in irrigation monitoring and management. Remote sensing is a valuable tool for determining the amount of area irrigated and resultant water allocation based on crop type and yield, evapo-transpiration, and soil characteristics. This information helps land managers and irrigation engineers assess the productivity of water use and maximize agricultural efficiency.

Geoffrey Henebry [South Dakota State University] presented research on land surface phenologies, land-cover and land-use change, and regional hydrometeorology in the Eurasian semi-arid grain belt. The research focusses on land-cover and land-use changes following the collapse of the Soviet Union and changes in regional hydrometeorology.

Programmatic Presentations

A total of 10 programmatic presentations were given during the meeting. Two of the presentations are summarized below.

Garik Gutman [NASA Headquarters] presented an overview of global satellite data products for LCLUC research, including the Mid-Decadal Global Land Survey (MDGLS) project and the Landsat Data Gap study. The MDGLS project is developing a global orthorectified data set from Landsat or Landsat-like observations based on measurements during 2004-2006. The project, led in phases by both U.S. Geological Survey (USGS) and NASA, uses Landsat 7 composites as the primary source, and uses data from Landsat 5, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Earth Observing-1/Advanced Land Imager (EO-1/ALI) to fill remaining gaps. Scene selection for North America and Africa are currently underway, and *GeoCover* images are being reprocessed using Shuttle Radar Topography Mission (SRTM) data for improved and consistent geodetic control.

The objective of the Landsat Data Gap Initiative is to identify, assess, and recommend alternative data sources that can best provide recurring global land observations, sufficiently consistent in terms of acquisition extent, frequency, and quality, as that of the Landsat Program. Systems considered include Indian Remote Sensing Satellite's (IRS) ResourceSat; China-Brazil Earth Resources Satellite (CBERS); MacDonald Dettwiler and Associates' (MDA) RapidEye; Surrey Satellite Technology Ltd's (SSTL) Disaster Monitoring Constellation (DMC); NASA's ASTER; GeoEye's IKONOS; DigitalGlobe's QuickBird; OrbImage's OrbView-3; France's Système Pour l'Observation de la Terre (SPOT); Japan Aerospace Exploration Agency's (JAXA) Advanced Land Observing Satellite (ALOS); and EO-1/ALI, with primary interest in India's ResourceSat-1 launched October 2003 and China/Brazil's CBERS-2 launched October 2003. Gutman presented a case for an international data initiative to generate a decadal data set (2009- 2011) prior to the launch of the Landsat Data Continuity Mission (LDCM).

Ailikun [CAS] presented the objectives and preliminary results of the Monsoon Asia Integrated Regional Study (MAIRS), a new initiative of the Integrated Regional Study under the leadership of the Earth Science Program Partnership (ESSP). The vision of MAIRS is to significantly advance the understanding of the interactions between the human and natural components of the Asian monsoon region (e.g., land-cover/land-use change, increasing aerosol emission, and water-use change) and the implications of these interactions for the global Earth system. MAIRS is also focused on integration of natural and social sciences in order to deliver strategies for sustainable development to the public and policy makers. Ailikun presented the results to date of the MAIRS study within the semi-arid/arid regions of China. She highlighted the discrepancy in precipitation between arid and semi-arid regions—an increase in precipitation and forest density observed in arid lands and a decrease in precipitation in semi-arid lands. The aerosol study concerned itself with the long distance transport of dust and observed that in one case, dusty clouds reduced the instantaneous net top-of-atmosphere cloud cooling effect by 30%. In conclusion, Ailikun recommended collaboration between MAIRS and NEESPI on their mutual regional interests within the drylands of Central Asia.

Breakout Discussion Groups

Four breakout discussion groups met to discuss current research priorities and opportunities for cooperation

and collaboration on the topics of land-use, ecosystems, water cycle, and modeling. In addition, the groups discussed issues such as framing primary research questions, data availability, methodology necessary to advance research in the field, and obstacles towards successful completion of research within their specific program fields.

Land Use

Joseph Messina [Michigan State University] and **Dan Brown** [University of Michigan] co-chaired the Land Use Group. The group devoted significant effort to framing the primary research questions within land-use and land-cover change research as they apply to drylands. Of key importance was identifying thresholds in the natural and/or human components of the natural-human dryland system which affect sustainability. Questions remain concerning the vulnerability, adaptive capacity, and resilience of these systems in the presence of land-use and land-cover change. The degree to which climate variability, water use, and other factors influence local land-cover and climate change must also be analyzed as a coupled system with the broader region. The team also addressed the degree to which social science data must be integrated with land-use and land-cover data. For example, population shifts and political factors may have an effect at the micro-scale and influence or create change on an observable macro-scale.

In order to address these science questions, the team identified the methodologies which would be required, their current deficiencies, the associated data needs, and other obstacles to success. They observed that there was a lack of a consistent methodological framework for interpreting and monitoring land-use on large scales and integrating *People and Pixels* together, but they theorized that inferring land-use from land-cover dynamics and employing data mining and integration methods might be reasonable approaches. Furthermore, they prescribed several methods for forecasting and modeling, including the following: scenarios (e.g., drought and dust), allocation (e.g., Changing Land Use and Estuaries [CLUE]), complex system models (e.g. cellular automata and agent-based models), and Markov and Von Thunen statistical approaches. The team recognized that a significant obstacle to the types of land-use research being discussed is lack of data—i.e., this type of research requires an increase in spatial or temporal detail, longer time series, and common framework for classification which does not mask subtle changes. In addition, researchers will have to deal with inter-annual variability issues, non-standardized multi-scale modeling frameworks, as well as the sometimes difficult issue of separating land-use from land management. These obstacles can significantly impede progress due to a lack of uniform data and models. However, near-term collaboration may help address these research questions and overcome obstacles by harmonizing data sets across international boundaries and enabling foreigners to collaborate within a region.

Ecosystems

Jiyuan Liu [CAS] and **Chen Xi** [CAS] co-chaired the Ecosystems Group. The team felt that the need for improved understanding of long-term ecosystem dynamics and the carrying capacity of ecosystems were key research topics. The group focused on the Millenium Ecosystem Assessment (MA), a five-year program designed to assess the consequences of ecosystem change for human well-being. In addition to the framework established by the MA, they also recommended development of indicator systems for identification of degradation of specific services, unified classifications of ecosystem boundaries, and integration of socio-economic data.

In addition to methodological frameworks, the discussions also highlighted the need for advancement of methodologies relating to scenario analysis, downscaling, and data fusion. Furthermore the most important data needs would seem to be long-term *in situ* and satellite data records, standardized data sources, and spatially-explicit socio-economic data. Difficulty in processing historical 1-km AVHRR data and limited availability of very high spatial resolution data remain as significant challenges to answering science questions. Collaboration between institutions within the region, including field research and observation stations, will enable significant advancement in ecological research. NEESPI can act as a key coordinator between U.S. and Central Asian countries and establish international joint observation stations (e.g., in the Altai Mountains bordering China and Mongolia).

Water Cycle

Natalya Agaltseva [Research Institute Uzhydromet] and **Alexander Shiklomanov** [University of New Hampshire] co-chaired the Water Cycle Group. The group focused on the atmospheric component of the water cycle, surface water, cryospheric water storage, and groundwater sources.

The primary research directions of the atmospheric component focused on weather monitoring and climate projections. The group recognized that *in situ* data are not sufficient in some regions and that current methodological frameworks are not adequate for convection parameterization and precipitation patterns in rough terrain. Further, the lack of high resolution climatic reanalysis data has proven to be a substantial obstacle to progress.

Surface water discussion focused on representation of the regional hydrological cycle and its interaction with

water use and management situations in order to provide reliable estimates of current conditions and future projections. There is a need for improved coherence among regional methodological approaches along with a unified regional hydrological database and reliable information on water and land-use. Major obstacles noted were trans-boundary river problems, lack of joint water management policies, and an overall decline of the observational network. Increased data, methods, and model sharing along with wider use of remotely-sensed data to complement *in situ* measurements could help overcome these obstacles.

The primary research focus of cryospheric water storage is understanding its state and fate. Reliable mountain glacier volume, snow depth, and snow water equivalent measurements are not yet accessible with remotely sensed data. Development of algorithms and methodologies to produce estimates using reasonably-priced data is needed to overcome this obstacle.

The groundwater sources discussion focused on realistic accounting of the clean water supply available for sustainable use and the need for water quality monitoring programs.

Modeling

Yongjiu Dai [Beijing Normal University] and **Dennis Ojima** [H. John Heinz III Center for Science, Economics and the Environment] co-chaired the Modeling Group. Priority areas identified by the group included: 1) the development of an integrated modeling framework; 2) cross-scale linkages and understanding across scale; and 3) further research on knowledge gaps impeding model development. The key issue regarding integrated modeling is developing a framework at an appropriate scale for socio-economic and environmental interactions in order to address science questions regarding regional development, land degradation, and sustainability. There is a need for downscaled climate projections and socio-economic trends to support local and regional scale planning, along with tools to validate models and increased input from stakeholders. A base spatial scale of 1 km was suggested as a starting point for understanding human-environment interactions. Cross-scale integration is also critical in order to improve data sharing and interaction between scale-dependent research communities, which in turn will support research on component linkages to fill current knowledge gaps.

NERIN Workshop

In addition to scientific presentations and breakout discussion groups on drylands research, the meeting also included a special workshop session on the final day regarding LCLUC regional support of both the NEESPI and Northern Eurasia Regional Information Network (NERIN) programs. **Olga Krankina** [Oregon State University] chaired the NERIN workshop that included presentations from:

- **Tatiana Loboda** [University of Maryland, College Park],
- **Jiaguo Qi** [Michigan State University],
- **Nadiya Muratova** [Ministry of Education and Science of the Republic of Kazakhstan],
- **Almaz Torgoyev** [Central Asian Institution of Applied Geocientists, Kyrgyzstan], and
- **Galina Stulina** [Scientific Information Centre of the Interstate Commission for Water Coordination of Central Asia, Uzbekistan].

In addition to the presentations above:

- **Dennis Ojima** [H. John Heinz III Center for Science, Economics and the Environment] led a discussion regarding a preliminary evaluation of the Land Cover Classification System (LCCS) and its application in dryland regions.
- **Chris Justice** [University of Maryland, College Park] and **Alexey Terekhov** [Ministry of Education and Science of the Republic of Kazakhstan] led a discussion on regional requirements for fire monitoring.
- **Jiaguo Qi** [Michigan State University] and **Olga Krankina** led a discussion on regional requirements and data needs for monitoring land-cover.

Recommendations from the fire and land-cover working sessions were as follows:

Fire

- Develop a network of regionally-specific validation sites to evaluate active fire product and burned-area product performances in drylands following international validation protocols.
- Provide coupled daily information on burned area together with active fires as a standard approach to fire monitoring in drylands.
- Include the optical information incorporating smoke as a way to enhance fire observations in drylands.

Land Cover

- Develop a LCCS-compatible map for the dryland areas of Northern Eurasia as a pilot project. The challenge is working together to create a regionally consistent map.
- Provide training through a series of workshops to ensure the correct application of the LCCS to mapping land-cover.

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ence removed. This approach will complement analysis based on sondes and provide more insight to the flow of ozone off the shores of the U.S.

Jennifer Logan [Harvard University] presented her analysis of the global impacts of the 2006 El Niño on biomass burning in Indonesia, and how the emission impacts propagated around the globe. The El Niño results in convection moving to the east, and in addition, there were large, drought-induced fires in Indonesia. Looking at the differences between 2005 and 2006, Logan sees that the CO anomaly over Indonesia persisted for two months, and the O_3 anomaly for three months.

Ray Nassar [Harvard University] followed Jennifer Logan's talk with a discussion of model simulations and causes for the anomalies observed in 2006. Using GEOS-Chem simulations, he found that the October/November 2006 anomalies clearly relate to increased Indonesian biomass burning during dry El Niño conditions. The persistent December O_3 anomaly may relate to lightning changes associated with the 2006 El Niño.

Gregory Osterman [JPL] reported on analysis of the impact of the Esperanza fire on Los Angeles air quality, and the use of TES data to support the Texas Air Quality Study. In close collaboration with the Texas state agency, analysis of Houston summertime events showed that a number were impacted by long-range transport of pollutants.

Line Jourdain [JPL] presented results of her research on the strength of lightning NO_x source over the U.S. Layers of enhanced ozone due to lightning NO_x are evident in the TES observations, and GEOS-Chem can replicate the spatial and temporal distribution of the ozone, but the magnitude is not replicated unless the lightning emissions are scaled. ■

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- A draft report on the findings of this workshop will be provided to the participants, and their input will be solicited and included in the final report.

Closing Remarks

Garik Gutman [NASA Headquarters] wrapped up the meeting with a review of NASA programmatic linkages, including Applications, Biodiversity, Terrestrial Ecosystems, and Water and Energy Cycle, as well as external national and international linkages, including the U.S. Climate Change Science Program (CCSP), GOFC/GOLD, and the IGBP-IDHP/GLP and iLEAPS under which NEESPI and MAIRS fall. Ongoing projects were noted, with new rounds of Interdisciplinary Science (IDS), EOS, and Achieving Competence in Computing, Engineering, and Space Science (ACCESS) projects, Water Cycle, Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), and Climate/LCLUC projects in their second year, and Carbon Cycle/LCLUC projects in their third year. New Carbon Cycle selections are being made now, and new LCLUC proposals were due October 1. Future directions for the LCLUC Program include integration of LCLUC processes in climate models and assimilation schemes, climate impact on land-use in terms of vulnerability, resilience, and adaptation, and enhancement of the social science component. Future plans for the program include an additional LCLUC call in ROSES-2008 to be published in January/February and due in October/November, increased LCLUC-MAIRS coordination, and further development of GOFC/GOLD regional networks, such as NERIN.

Future Meetings

The upcoming Spring LCLUC Science Team Meeting will be held May 1-2, 2008 in conjunction with the NASA Carbon Cycle and Ecosystems Focus Area Joint Science Workshop (April 28-30, 2008) at the University of Maryland University College (UMUC) Conference Center. More information concerning this meeting along with presentations from the Urumqi meeting can be found on the LCLUC website at: *lcluc.hq.nasa.gov.* The Fall 2008 LCLUC Science Team meeting will be organized jointly with the MAIRS program and held in Southeast Asia. The focus of the meeting will be on LCLUC in the Asian tropics. The NEESPI Plenary (all-hands) Science Team meeting will be held in Helsinki, Finland on June 2-6. Details on this and other NEESPI meetings can be found at: *neespi.org.* ■