meeting summaries

# Summary of the Spring 2018 NASA Land-Cover and Land-Use Change Science Team Meeting

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The 2018 NASA Land Cover and Land Use Change (LCLUC) program's Science Team Meeting was held April 3-5, 2018, at the Marriott Washingtonian Center, located in Gaithersburg, MD. The meeting featured invited presentations, reports from the LCLUC Science Team members funded as a part of South and Southeast Asia Research Initiative (SARI), as well as Synthesis Projects from Research Opportunities in Space and Earth Sciences (ROSES) 2015 selections. Poster presentations with lightning talks highlighted recent results from ongoing LCLUC-related research, including the Interdisciplinary Research in Earth Science (IDS) Program and the New Investigator Program (NIP), as well as introductions of the most recently selected LCLUC-funded projects. The last day of the meeting focused on the final results from the first round (2014) LCLUC Multi-Source Land Imaging (MuSLI) projects (which are listed at *http://lcluc.umd.edu/content/multi-source-land-imaging-musli*), the status of the Harmonized Landsat–Copernicus Sentinel-2[1] (HLS) data initiative (*https://hls.gsfc.nasa.gov*), and future interactions with the Landsat Science Team.[2]

[1] The European Space Agency's Sentinel missions were developed specifically to meet the operational needs of the Copernicus comprehensive Earth-observing program. Each Sentinel mission is based on a constellation of two satellites to fulfill revisit and coverage requirements, providing robust datasets for Copernicus services. The two mentioned in this article are Sentinel-1, a synthetic aperture radar mission, and Sentinel-2, a land-imaging mission with resolution comparable to that of Landsat. To learn more about the Sentinel missions, visit *https://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Overview4*.

[2] To read a summary of the 2017 Summer Landsat Science Team Meeting, see the January–February issue of *The Earth Observer* [**Volume 30**, **Issue 1**, pp. 21-25—*https://eospso.gsfc.nasa.gov/sites/default/files/eo_pdfs/Jan_Feb_2018_color508_0.pdf#page=21*].

This year's meeting was highly successful, with about 120 participants from across the country including LCLUC principal investigators (PIs), research collaborators, post-docs, LCLUC-funded graduate students, researchers from the U.S. Geological Survey (USGS), NASA, and even a high school student conducting LCLUC-related research at NASA's Goddard Space Flight Center (GSFC).

**Day One**

**Garik Gutman** [NASA Headquarters (HQ)—*LCLUC Program Manager;* see photo below] kicked off the meeting by stating that since the program's inception over 300 projects have been funded, and socioeconomic components to land use research is one of the program's priorities. He showcased the success of the program's regional initiatives including SARI, Northern Eurasia's Future Initiative (NEFI), and the Monsoon Asia Integrated Research for Sustainability (MAIRS) under


LCLUC program manager, **Garik Gutman**, sets the science trajectory for the meeting, associated discussion sections, and lightning talks. **Photo credit:** Catherine Nakalembe

A group picture showing the meeting participants on the first day of the meeting, including scientists, graduate students, program managers, collaborators, principal investigators, and other LCLUC community members. **Photo credit:** Kristofer Lasko

Future Earth's Asia Initiative.[3] Gutman emphasized the importance of the LCLUC program's capacity building activities such as training, often included before or after LCLUC regional meetings coordinated through strong partnerships with SERVIR[4] and SilvaCarbon,[5] space agencies such as the Geo-Informatics and Space Technology Development Agency (GISTDA, Thai space agency), and nongovernmental organizations such as the SysTem for Analysis, Research and Training (START) program. **Chris Justice** [University of Maryland, College Park (UMD)—*LCLUC Program Scientist*] spoke after Gutman's overview, and reviewed the goals and objectives of the meeting.

**Jack Kaye** [NASA HQ—*Associate Director of Research for NASA's Earth Science Division*] gave an invited presentation. He recognized the good work being undertaken by the program, provided a summary of current and upcoming NASA missions, and announced that the LCLUC program will continue to receive funding to continue its interdisciplinary research. Kaye answered questions from the audience and noted that NASA is supportive of including data from international satellite assets and commercial data providers to address Earth system science. He also pointed out the improved capabilities of geostationary satellites for high-temporal-resolution monitoring of the land surface, e.g., for land cover change relating to wildland fires, and monitoring of urban areas with frequent observations of night lights and their changes.

**Ariane de Bremond** [Global Land Programme (GLP)—*Executive Officer*] reviewed the GLP science themes, which focus on linking sustainable land systems using modeling, monitoring, and case study syntheses of specific topics, e.g., land-use conflict, land governance, land-management systems, urban-rural interaction, and global sustainable development. LCLUC research is a major focus for GLP; it continues to nurture a network of internationally renowned scientists, nodal offices, and working groups, and pursues partnerships with many programs including Future Earth and the United Nations International Land Coalition. During the discussion that followed, a clear connection between GLP and the NASA LCLUC program surfaced. The GLP has strong linkages with societal applications and benefits resulting from LCLUC research, making a partnership with the NASA program very useful.

One major part of the meeting included a series of presentations within the SARI component of the LCLUC program. **Krishna Vadrevu** [NASA's Marshall Space Flight Center (MSFC)] began with a discussion about the origin of the SARI program. He explained that the concept arose from discussions following a field trip during a regional meeting in Kerala, India in 2013. Shortly after that, Vadrevu—along with other LCLUC researchers, **Ruth DeFries** [Columbia University], **Rama Nemani** [NASA's Ames Research Center], **Karen Seto** [Yale University], and **Dan Brown** [University of Washington]—consulted with Garik Gutman and Chris Justice to further develop the idea. With a common goal, SARI leverages the research being undertaken at NASA and regional institutes and universities with science capacity-building activities being undertaken by a large network of nonprofit organizations, universities, and programs such as NASA SERVIR.

Following Vadrevu's opening remarks on SARI, representatives of 13 LCLUC–SARI funded projects gave presentations. All of the talks focused on activities in South Asia. Specific presentation topics in this session included: forest change monitoring, agriculture land use and food security, disease transmission, LCLUC and armed conflict, urban growth challenges, sustainable livelihoods in rural communities, drivers of forest plantation establishment, forest change and degradation monitoring, consequences of changes in mangrove forests attributed to land use change such as shrimp farming expansion as well as natural processes of erosion—all with implications on carbon storage, biodiversity, and the economy; demographic change and related LCLUC, coastal zone impacts of LCLUC, and progress in cropland monitoring with remote sensing.

**Krishna Vadrevu** highlighted that the SARI program has been productive in recent years, citing as examples publication of a book on land–atmosphere interactions and several compilations of special issues of peer-reviewed journals such as *Environmental Research Letters*, *Environmental Pollution*, *International Journal of Remote Sensing*, *Journal of Environmental Management*, and *International Journal of Digital Earth*. Following the presentations, Vadrevu led a discussion session, during which he noted that the current round of SARI projects has focused on specific case studies in countries such as Nepal, India, and Myanmar. However, broader LCLUC issues applicable to large spatial scales will be needed as a focus for future projects. In addition, participants agreed on the need for regional

[3] Future Earth is a ten-year international research program launched in June 2012 at the United Nations Conference on Sustainable Development (Rio+20) that is intended to provide critical knowledge required to face the challenges posed by global environmental change and to identify opportunities for a transition

[4] SERVIR, a joint venture between NASA and the U.S. Agency for International Development provides state-of-the-art, satellite-based Earth monitoring, imaging and mapping data, geospatial information, predictive models and science applications to help improve environmental decision making among developing nations in eastern and southern Africa, the Hindu-Kush region of the Himalayas, and the lower Mekong River Basin in Southeast Asia. SERVIR is not an acronym; it is derived from a Spanish word meaning "to serve."

[5] SilvaCarbon is an interagency technical cooperation program of the U.S. government organized to enhance the capacity of selected tropical countries to measure, monitor, and report on carbon in their forests and other land-surface types.

LCLUC and water resources management projects, as this is an area of international concern. **Jiaguo Qi** [Michigan State University] is leading one such project studying the impact of the Mekong River (Vietnam) dam, which is part of Future Asia/MAIRS and NASA Interdisciplinary Sciences.

The participants also reiterated the need for an effort to bring together disparate funding sources to strengthen science capacity in the region to make better use of Earth observations data by leveraging partnerships, funding, and yielding larger educational payoffs. In the discussion that ensued, the participants recognized the benefit of a stronger connection with the GLP to increase the policy impact of LCLUC science. This strengthened partnership would be especially timely, as several SARI projects are reaching maturity. **Dan Brown**, **Jeff Fox** [both from East-West Center[6]], and other SARI members highlighted that local-scale SARI research results and processes should soon be applied to broader regional-scale themes, thereby increasing the impact of those research efforts. In addition, there will be future SARI projects that synthesize the local and national-level research to provide a broader regional perspective and inform the relevant science applications. Also, in the coming years, impactful SARI-wide review articles are anticipated that will make a contribution to broader LCLUC science. **Chris Justice** stressed the need for LCLUC PIs to leverage regional science meetings in SARI countries, as an opportunity to develop grants with local country scientists for co-funded research [e.g., with United States Agency for International Development (USAID) or regional development banks] to address the current gap in science findings and to aid in decision making. Various other issues were raised during the discussion section, including how to better communicate science findings that have policy implications, beyond using peer-reviewed research publications.

**Day Two**

The second day of the meeting focused on international linkages and capacity building in the South/Southeast Asia region. **Krishna Vadrevu** presented on how SARI connects with the NASA SERVIR program to facilitate improved international training for young scientists in South/Southeast Asia. He also shared recent SERVIR program highlights on behalf of **Nancy Searby** [NASA HQ]. Specific to the Southeast Asia region, the SERVIR program has a SERVIR-Himalaya hub in Kathmandu, Nepal, and also a hub in the Lower Mekong Delta. SERVIR-Himalaya has conducted recent projects assisting with agricultural drought warning and geovisualization systems for water monitoring. The Lower Mekong Delta hub has developed partnerships with international research institutions and has provided useful tools and training driven by application needs across its four thematic areas of agriculture and food security, water resources, land cover and ecosystems, and weather and climate. Some example projects of note include a regional land-cover-monitoring system as well as web-based tools for flood-damage assessment. These and other applications are driven by user demand and are implemented through partnerships with Global Forest Watch[7], University of Maryland, SilvaCarbon, and many other regional partners.

**Jiaguo Qi** gave a presentation about the MAIRS and Future Earth's Asia Initiative, which provided a clear opportunity for collaboration between the MAIRS and SARI.There are already plans underway to conduct a science meeting to be held jointly with associated capacity-building activities in the Southeast Asia region.

The LCLUC program has traditionally funded synthesis projects, which pull together project findings to further develop a broader regional understanding and strengthen the theoretical underpinning to regional LCLUC science. Included among the presentations and posters were several that focused on current LCLUC synthesis projects including: **Steve Walsh** [University of North Carolina] who reported on LCLUC island processes; **Ariane de Bremond,** who discussed socio-environmental synthesis of the global land rush; and **Randolph Wynne** and **Valerie Thomas** [both from Virginia Tech], who presented information on region-specific LCLUC drivers of transition and future scenarios for the Southeast U.S. In coming years synthesis projects derived from SARI countries will be solicited.

A poster presentation closed out the second day of the meeting. It featured 30 posters with a wide range of topics. A list of all presentations can be downloaded from the LCLUC website at *http://lcluc.umd.edu/sites/default/files/lcluc_documents/LCLUC_2018_posterPresentations.pdf*.

**Day Three**

The third day of the meeting was dedicated to the MuSLI section of the LCLUC program. **Jeff Masek** [GSFC—*MuSLI Project Scientist*] led this portion of the meeting. The MuSLI team consists of full-scale continental/global scale products (called *Type I* projects) and

[6] The East–West Center was established by the U.S. Congress in 1960 to promote better relations and understanding among the people and nations of the United States, Asia, and the Pacific through cooperative study, research, and dialogue. Learn more at *https://www.eastwestcenter.org/about-ewc/mission-and-organization*.

[7] Global Forest Watch (GFW) is an online platform that provides data and tools for monitoring forests. By harnessing cutting-edge technology, GFW allows anyone to access near-real-time information about where and how forests are changing around the world. Learn more at *https://www.globalforestwatch.org*.

regional prototype products (called *Type II* projects).[8] Both types are focused on developing innovative approaches and datasets using multiple sensor data (i.e., Sentinel-1, Sentinel-2, Landsat 8). The HLS Surface Reflectance Product is a core product for MuSLI, representing the most widely accessible multispectral, medium-to-high spatial resolution satellite data. The synergistic use of the Sentinel-1, Sentinel-2, and Landsat 8 sources provides unprecedented opportunities for timely and accurate observation of land surface dynamics at improved temporal frequencies—previously unachievable at this spatial resolution. Activities to harmonize data products have been funded by the LCLUC program since 2014, including a new round of funded projects in 2018. Sample data are now accessible at *https://hls.gsfc.nasa.gov*.

**David Roy** [South Dakota State University] showcased a combined Landsat 8–Sentinel-2 burned-area product that offers potential for improved small-fire burn detection; the output of the first stage of production is to be released for Africa. He also presented improved coregistration software for combined Landsat 8–Sentinel-2 (*https://openprairie.sdstate.edu/landsat_sentinel_registration/2*).

This session focused on the results from the first round of MuSLI-funded projects. It included wrap-up presentations from several MuSLI investigators. **William Salas** and **Nathan Torbick** [both affiliated with Applied GeoSolutions] described their effort to develop near-real-time and operational rice mapping products including drought assessment and impacts on rice production. **Joseph Sexton** [UMD] reported on global tree- and water-cover mapping. **Chris Small** [Columbia University] summarized his research on urban growth and infrastructure through development of a physically based, satellite-derived index to map human settlement patterns, changes, and quantifying co-evolution of settlement networks across the landscape through time.

There were also presentations from **Matthew Hansen** [UMD] on multisource methods for improving crop type mapping, area estimation, and sampling methods in the U.S., as well as **Mark Friedl** [Boston University] on seasonal dynamics of land surface phenology integrating multiple satellite observations—see **Figure 1**, and **Chengquan Huang** [UMD] on near-daily inundated area mapping with SAR and optical datasets over North America.

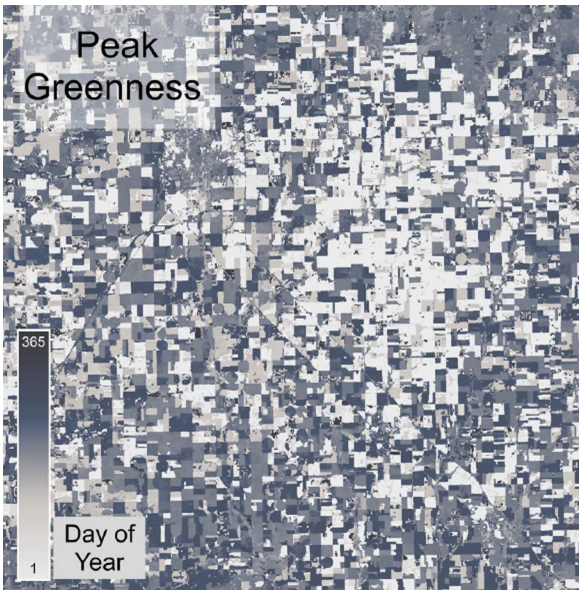


**Figure 1**. An example of a MuSLI project result from using combined Landsat 8 and Sentinel-2 satellite data product to map the day of peak vegetation greenness over a cropland area of Kansas. **Image credit**: Mark Friedl

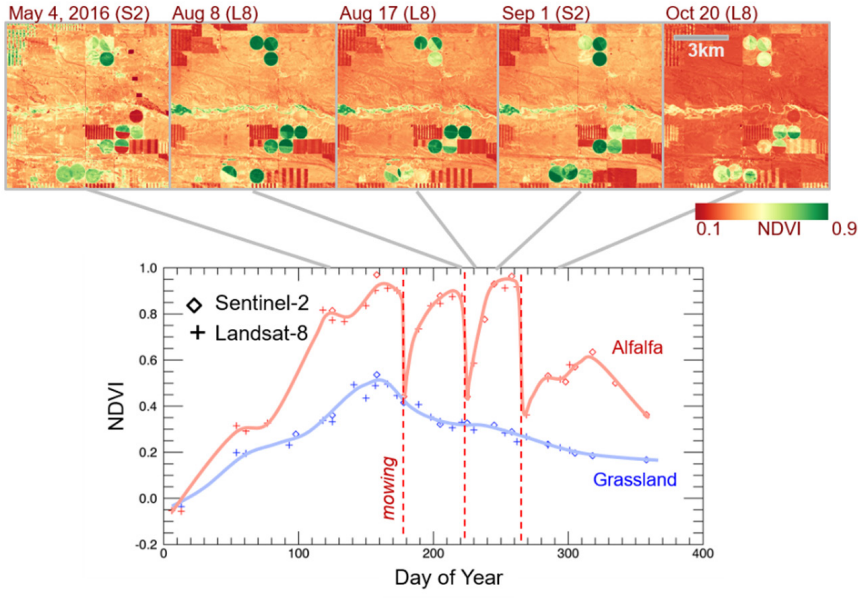


**Figure 2**. HLS product example shown with Sentinel-2 (S2) and Landsat 8 (L8) integrated together showing seasonal phenology (greening) for natural grassland and irrigated alfalfa fields near Cheyenne, WY, between May and October 2016, observed from Harmonized Landsat 8/Sentinel-2 data products. The high temporal density of observations allows individual mowing events to be detected within alfalfa fields. **Image credit**: From Jeff Masek's presentation

[8] MuSLI Type I projects integrate previously demonstrated algorithms and dataset validation, but applied to multiple satellite dataset integration and with data processing costs supported by NASA. In contrast, MuSLI Type II projects focus on developing algorithms and products at a regional scale, especially in order to demonstrate feasibility of a global scale product.

A new feature of this meeting as compared to previous years was the addition of *lightning talks* from the eight most recently funded MuSLI projects (2018-2020), with topics including: land-surface phenology, various agricultural applications (i.e., agricultural abandonment, crop yield mapping), and land-surface temperature. One novel project (led by Petya Campbell) is mapping vegetation function and chlorophyll content. The lightning talk approach helped the broader LCLUC community to become familiar with scientists newly working in these areas and to get an idea of the trajectory for the latest in cutting-edge research topics.

**Jeff Masek** and **Chris Crawford** [USGS—*Landsat Science Team*] were pleased to share that progress has been made in combined multisensor products, e.g., surface reflectance using Sentinel-2 and Landsat 8—e.g., see **Figure 2** on page 17. Moreover, there has been progress in integrating the Sentinel-1 Synthetic Aperture Radar data with optical observations. MuSLI scientists discussed challenges with geolocation errors, lack of reprocessing with Sentinel-2, which makes it difficult to implement changes to previously collected or already-processed datasets; cloud masking with Sentinel-2, due to lack of thermal band; and the Sentinel-2 tiling system, which has overlap issues. Efforts are underway to address these problems and to forward any new instrument and data issues to ESA. The participants agreed that a stronger linkage should be made between the NASA MuSLI "Science Team"[9] and the newly selected Landsat Science Team with the possibility of joint meetings, as there is considerable overlap of team members.

**Concluding Remarks**

**Garik Gutman** adjourned the meeting. In his concluding remarks he emphasized three key points about the NASA LCLUC program:

1. It is a global program, supported through regional partnerships to enhance regional scientists' access to NASA's remote sensing assets and, conversely, NASA's scientists' access to international data (i.e., data from various governments currently limited in data sharing activities), and field data collection.

2. It acts as a catalyst to further regional science initiatives through networks, by leveraging national, regional, and local knowledge and resources to strengthen NASA's research projects, with regular regional workshops on land-use science and societal priorities.

3. It is a promoter of science capacity building through international data sharing and training on the use of NASA science data.

[9] Officially, NASA does not consider MuSLI Team a science team; however, within the context of the LCLUC Program they function as a science team, with a "project scientist" assigned by the LCLUC program manager.

Gutman indicated that in the coming years, LCLUC will continue regional science funding such as for SARI and NEFI, while also better balancing geographic and thematic research foci, including a renewed focus on Latin America and other regions of the world, while also continuing projects in North America. The continued funding of social science research is critical for LCLUC science as investigators seek to understand the underlying processing driving land cover changes. There is also a need to analyze and synthesize the results from the first and second rounds of SARI and MuSLI projects, and to continue to build upon the success of such international efforts by better integrating networks with other space agencies such as ESA and programs such as the GLP, European Association of Remote Sensing Laboratories (EarSEL), and others.

Overall, the LCLUC Science Team Meeting succeeded in its objective of bringing together LCLUC researchers from across the country to further develop project partnerships and collaborations, address and improve upon ongoing issues relating to multi-source data integration, and collect community feedback regarding LCLUC science and continuing to keep the LCLUC program focus in line with community needs. Looking forward, the next LCLUC-related meeting is the LCLUC/SARI regional science team meeting, to take place in August 2018 in Southeast Asia (location to be determined; visit *http://sari.umd.edu* for updates). Meanwhile, the next LCLUC Science Team Meeting will take place during April 2019 with final details forthcoming (check *http://lcluc.umd.edu* for updates in late autumn or early winter). Members of the NASA LCLUC community are strongly encouraged to register early and attend. ■