Landsat Science Team Summary

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Meeting Overview

The Landsat Science Team—sponsored by the U.S. Geological Survey (USGS) and NASA—met in Boise, ID, June 17–19, 2010. Landsat Science Team member **Rick Allen** [University of Idaho] and the staff of the Idaho Department of Water Resources hosted the meeting.

Tom Loveland and **Jim Irons** [USGS and NASA Goddard Space Flight Center (GSFC), respectively—*Landsat Science Team co-chairs*] opened the eighth meeting of the Landsat Science Team. They stated that the focus of the meeting was the review of Landsat and Landsat Data Continuity Mission (LDCM) status and the science and applications activities of the Landsat Science Team members. **Curtis Woodcock** [Boston University—*Landsat Science Team Leader*] added his perspective on the need to continue working toward operational status for the Landsat program. All presentations from the meeting are available at: *landsat.usgs.gov/science_june2010MeetingAgenda.php*.

Bryant Cramer [USGS—*Associate Director for Geography*] provided a summary of three recent Landsat events. First, he summarized USGS progress in developing the LDCM ground system. Because of budget issues, the ground system has been rescoped, redesigned, and rebudgeted, but it has not lost any functionality. The successful Critical Design Review is evidence of the positive impact of the ground system changes. Second, the recently released National Space Policy emphasizes the importance of operational land imaging and the importance of international cooperation. These emphases increase the importance of the technical and scientific discussions underway with the European Space Agency (ESA) on Sentinel-2 and LDCM operations compatibility. Cramer also noted that the operational land imaging element of the policy could be an important driver for Landsat 9 authorization. He stressed the importance of continuing Landsat as a science-driven mission, and he challenged the Landsat Science Team to define an acceptable risk of a data gap in an operational Landsat program (e.g., what is the cost of not having Landsat coverage for specific periods?). Finally, Cramer noted that the USGS is reorganizing: by fall, all programs will be aligned with science themes (i.e., climate variability and change, ecosystems, water, hazards, and energy and minerals) rather than disciplines.

Brad Doorn [NASA Headquarters—*Program Manager for Agriculture, Carbon, and Water Applications in the Applied Science Program*] followed with a NASA Headquarters perspective on Earth science and Earth observation. Doorn said that NASA is committed to a December 2012 LDCM launch. He also added that Cramer's push for Landsat 9 is important to all Earth science activities and that there was a need to better explain the benefits of links between Landsat observations and other Earth observation capabilities such as the Hyperspectral Infrared Imager (HyspIRI); Deformation, Ecosystems Structure and Dynamics of Ice (DESDynI); and Visible/Infrared Imager Radiometer Suite (VIIRS).

Landsat Updates and Related Reports

Kristi Kline [USGS—*Landsat Project Manager*] reported that Landsats 5 and 7 continue to add to the global archive. Due to recent problems with the Landsat 5 Traveling Wave Tube Amplifier (TWTA), a new collection schedule has been adopted using cloud avoidance and a 50% duty cycle. Collection schedules may change again in the future depending on TWTA status.

Rachel Headley [USGS—*Landsat Project*] provided status on the Landsat Global Archive Consolidation (LGAC). The goal of LGAC is to repatriate all internationally acquired Landsat data (estimated at over 3 million scenes) to the USGS archive. The USGS is engaged with the international ground stations and, as of June 2010, has repatriated 50,000 scenes.

Holly Miller, Natalie Sexton, and Lynne Koontz [all from USGS Fort Collins Science Center] presented survey results about users, uses, and the value of Landsat data in the U.S. Over 2,500 users responded to the survey, providing a rich dataset for trending and cost-benefit analysis.

Jeff Masek [GSFC—*LDCM Project Scientist*] summarized progress on the 2010 Global Land Survey (GLS). Acquisition of the required scenes is underway, with uniform processing of the GLS 2010 dataset planned for Spring 2011.

Noel Gorelick [Google.org] spoke about Landsat, cloud computing, and the *Google Earth Engine*.

Landsat Data Continuity Mission (LDCM) Status

Bill Ochs [GSFC—*LDCM Project Manager*] gave a detailed account of LDCM mission status and schedule. A successful Mission Critical Design Review (MCDR)

was conducted May 25-27. Operational Land Imager (OLI) hardware was moving toward integration and testing, and several important milestones were reported concerning the spacecraft build. In terms of schedule, total project funded reserve to launch stood at about six months, and the project remained committed to a December 2012 launch date.

Dennis Reuter [GSFC] reviewed progress on Thermal Infrared Sensor (TIRS) development. TIRS successfully completed a Critical Design Review (CDR) in April. All systems were meeting their requirements, and the schedule, while aggressive, was being met.

Dave Hair [USGS—*Acting LDCM Project Manager*] described significant progress on various elements of the Ground System (GS), leading up to a successful CDR in March. A series of Ground Readiness Tests (GRTs) were scheduled and underway. Hair reported sufficient budget and schedule reserve for successful GS development and implementation by the USGS.

John Schott [Rochester Institute of Technology] reported that the first simulated OLI images were being generated by the Digital Imaging and Remote Sensing Image Generation (DIRSIG) system, and that emphasis would be shifting to modeling of TIRS and other scene and sensor characteristics.

Idaho and Intermountain West Remote Sensing Activities

Nancy Glenn [Idaho State University], **Keith Weber** [Idaho State University], **Lee Vierling** [University of Idaho], **Alejandro Flores** [Boise State University], and **Brian Schwind** [U.S. Forest Service (USFS) Remote Sensing Applications Center (RSAC)] highlighted Landsat-related activities occurring in the meeting locale.

Science Team Member and Associates Presentations

Dennis Helder [South Dakota State University] described recent Landsat calibration activities. For Landsat 5, a relative gain update was derived to reduce striping. A Modulation Transfer Function (MTF) correction was presented that reduced blur in Landsat 4 imagery. Finally, Helder reported that with the recent completion of Multispectral Scanner (MSS) calibration, a consistent absolute radiometric calibration of all Landsat sensors had been accomplished.

Jeff Masek briefed the members on considerations for implementing an operational surface reflectance product for Landsat.

Eric Vermote [University of Maryland, College Park (UMCP)] provided an update of his work developing and evaluating Landsat atmospheric correction and cloud masking. Surface reflectance evaluation is ongoing through several independent efforts. The cloud-masking approach performs well, while cloud-shadow masking needs further investigation.

Feng Gao [Earth Resources Technology, Inc./GSFC] described results of a Landsat Advanced Very High Resolution Radiometer (AVHRR) data fusion study, and examined Landsat within-scene Bidirectional Reflectance Distribution Function (BRDF) effects. Landsat–AVHRR Normalized Difference Vegetation Index (NDVI) fusion products can be used to produce consistent phenological metrics, but AVHRR data quality is generally inferior to that from the Moderate Resolution Imaging Spectroradiometer (MODIS). Within-scene Landsat view angle effects were smaller than solar angle and seasonal phenology variations, but were significant enough to merit correction for some applications.

Lazaros Oreopoulos [GSFC] applied an approach developed for MODIS to a test set of Landsat scenes for discriminating between cloud, cloud shadow, vegetated land, non-vegetated land, water, and snow/ice. Cloud fraction estimates were similar to the Automated Cloud Cover Assessment (ACCA).

Rick Allen [University of Idaho] discussed several evapotranspiration (ET) investigations using Landsat. Satellite overpass frequency is a major factor in successful calculation of growing season ET. Probabilities for success were estimated at 80% (4-day return), 40–50% (8-day return), and 5% (16-day return). Allen also reviewed ET-based applications in water management, with emphasis on seven western states.

Martha Anderson [U.S. Department of Agriculture (USDA) Agricultural Research Service] presented results of data fusion approaches for ET mapping. MODIS–Landsat daily ET fusion appears feasible and can be optimized when MODIS and Landsat are flying in formation. Two or more Landsats collecting data continue to be a critical need. Consistent Leaf Area Index (LAI) products derived from MODIS and Landsat would also be valuable.

John Schott [RIT] spoke about LDCM's potential for monitoring inland and coastal waters. Schott demonstrated through modeling that improvements in OLI radiometry can reduce errors in estimating suspended material and organic matter concentrations by nearly a factor of four when compared to the Enhanced Thematic Mapper Plus (ETM+). The effects of over-water atmospheric corrections were also examined.

Bonnie Ruefenacht [USFS-RSAC] described a process for continental compositing of MODIS data and subsequent change detection to prioritize sketch mapping and aerial surveys for forest health applications.

Warren Cohen [USFS] surveyed the use of Landsat data in the U.S. Forest Service. The agency has a rich history of Landsat-based research and applications, including vegetation mapping, fire modeling, habitat studies, insect and disease risk mapping, disturbance monitoring, and forest inventory data integration. Landsat use has increased significantly over time and has now become a fundamental resource in meeting several agency requirements.

Randy Wynne [Virginia Tech] provided evidence that Landsat has become an essential tool for forest monitoring, modeling, and management. Analysis of data through time, including interannual chronosequences, has become increasingly routine. Landsat data also improve the precision and spatial specificity of ecosystem process models. State-of-the-art, Landsat-based decision-support tools are now feasible.

Jeff Masek presented a case study that used Landsat and other data to detect biome boundary shifts in Northern Quebec, Canada. Landsat, MODIS, and AVHRR data provided strong evidence for recent greening in the study area. The Landsat archive, when combined with other remote sensing and field data sources, provides the means for characterizing climate-driven shifts in global vegetation patterns.

Alan Belward [European Commission Joint Research Center] evaluated the impact of the GLS and USGS open archive policies on surveys of deforestation in the tropics. Belward concluded that open policies, archive depth, and robust products make Landsat the only viable means of measuring deforestation from the 1990 baseline to the present.

Sam Goward [UMCP] examined issues of cloud contamination and observation frequency in the context of operational monitoring of interannual land dynamics. Results suggested that for mid-latitude eastern North America, a daily overpass would be needed to yield near-weekly usable coverage.

Darrel Williams [Global Science & Technology, Inc.] introduced the Land Observations Globally in a Cost-effective Augmentation of Landsat (LOGICAL) concept. The general idea is that low-cost, small-satellite missions can be used effectively to augment Landsat's spatial and temporal coverage.

Jim Vogelmann [USGS] investigated Landsat image mosaics and composites from a user's perspective. Recommendations included generating monthly composites for predefined epochs, considering alternatives to maximum-value-based compositing, and extending current Landsat 7 approaches to include Landsat 5 and MSS data.

Curtis Woodcock described a Landsat–MODIS fusion method for monitoring land change in near-real time, which appears feasible at Landsat scale but depends on the use of every observation available, even scenes with a high degree of cloud cover. Woodcock finished by encouraging the group to be more systematic about providing a comprehensive history of the Earth's surface in the Landsat era and to keep moving toward real-time monitoring to better inform land management.

Mike Wulder [Canadian Forest Service] closed the meeting with the status on Landsat research and product development. Activities included feature-based change attribution, habitat modeling, fragmentation studies, long time-series analysis, and synthetic imaging. Composite and fusion products have advanced considerably, but further iterations are necessary to establish operational standard products that address community and policy needs.

Future Meetings

The next Landsat Science Team meeting will take place March 1–3, 2011 in Phoenix, AZ. The meeting will focus on LDCM development status and preparations for LDCM data use in 2013.