meeting/workshop summaries

Landsat Science Team Meeting Summary

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Meeting Overview

The Landsat Science Team sponsored by the U.S. Geological Survey (USGS) and NASA met in Mesa, AZ, from March 1-3, 2011. The team met in Mesa so that they could receive briefings and tours of the Landsat Data Continuity Mission (LDCM) spacecraft that is being developed by Orbital Sciences Corporation in nearby Gilbert, AZ.

Tom Loveland and **Jim Irons** [USGS and NASA Goddard Space Flight Center (GSFC), respectively—*Landsat Science Team Co-chairs*] opened the ninth meeting of the Landsat Science Team. They stated that the primary focus of the meeting was the in-depth review of LDCM development status, but that Landsat 5 and 7 activities and future Landsat missions would also be discussed. Loveland commented that the meeting marked the beginning of the final year of the team but that the USGS plans this year to issue a request for proposals to continue the team for an additional five years. Irons noted that the LDCM development is on schedule, and that all major systems are in the integration and test phase of their development. He also mentioned that Bill Ochs has left his position as the LDCM Project Manager to lead the NASA James Webb Space Telescope and that Phil Sabelhaus now leads LDCM. The team offered a round of applause in recognition of Bill's outstanding leadership and commitment to science.

Curtis Woodcock [Boston University—*Landsat Science Team Leader*] concluded the opening session by reminding everyone of the major Landsat accomplishments achieved over the previous four years (e.g., no-cost Landsat data, global archive consolidation, Sentinel-2[1] coordination, Landsat science products, and LDCM progress). He then challenged the team to focus their attention on bigger accomplishments over the next five years.

Meeting presentations are available at: *landsat.usgs.gov/science_LST_mar1_3_2011.php*

USGS Landsat Science and Development

Matt Larsen [USGS—*Associate Director for Climate and Land Use Change*] introduced himself to the team and described the recent USGS realignment. The USGS is now organized into mission areas. Land Remote Sensing and Landsat activities are part of the Climate and Land Use Change Mission that Larsen leads. Larsen explained the importance of remote sensing for USGS climate and land use research, and reported on efforts to stabilize the future of Landsat. The President's Fiscal Year 2012 budget includes funding to: 1) estab-

[1] Sentinel 2 is a mission under the European Space Agency's Living Planet Programme. The pair of Sentinel-2 satellites will routinely deliver high-resolution optical images globally, providing enhanced continuity of Système Pour l'Observation de la Terre (SPOT)- and Landsat-type data.

Landsat Science Team meeting participants

lish a National Land Imaging Program in the Department of the Interior (DOI) and the USGS; 2) develop Landsat 9; and 3) authorize planning for Landsat 10. Future Landsat missions would be led by the USGS and developed through a NASA–USGS partnership.

Bruce Quirk [USGS—*Land Remote Sensing Program Coordinator*] led a discussion of the steps that resulted in the President's Landsat request. The National Space Policy released in mid-2010 placed operational land remote sensing responsibilities with the DOI. With the National Land Imaging Program the DOI, through the USGS, would be responsible for documenting the Federal requirements for land remote sensing data and for developing strategies to meet priority needs. Equally important, the President's budget *operationalizes* the Landsat program and authorizes the development of Landsat 9 and 10. Preliminary plans call for a Landsat 9 launch in late 2018, and Landsat 10 in 2023. Quirk said that in the coming months, USGS would be developing Landsat 9 mission requirements and identifying the key trade studies that will lead to the establishment of Landsat 9 capabilities.

The Operational Land Imager (OLI) being integrated onto the LDCM spacecraft.
Photo Credit: Ball Aerospace Technology Corporation

John Dwyer [USGS—*LDCM Project Scientist*] reviewed preliminary USGS plans to collect, analyze, and prioritize land remote sensing requirements. The plans include identification of key science and applications needs, measurements, product specifications, and services needed to make effective use of land remote sensing data and products.

Landsat Data Continuity Mission (LDCM) Status

Dell Jenstrom [GSFC—*LDCM Deputy Project Manager*] provided status on the instruments, spacecraft, and mission operations components of the LDCM project. The launch readiness date is December 1, 2012, with three months of schedule reserve. The Operational Land Imager (OLI) has completed integration and performed very well during spatial and radiometric testing. Once environmental testing is complete in June, the instrument will be shipped to the spacecraft vendor. The Thermal Infrared Sensor (TIRS) and spacecraft bus have each started integration and testing.

Betsy Forsbacka [GSFC] detailed TIRS activities and plans. Since July 2010 the focal plane array, electronics, and telescope have been completed. Other subsystems such as the cryocooler, scene-select mechanism, and main electronics box are nearly complete. Final delivery of TIRS to the spacecraft vendor is planned for December 31, 2011.

Brian Markham [GSFC] spoke about LDCM on-orbit calibration and validation considerations. The mission orbit plan is a 16-day repeat cycle with an 8-day phase shift relative to Landsat-7. The ascent plan indicates a four-day period where LDCM will underfly Landsat-7 for cross-calibration. These plans may vary depending on the operational status of Landsat-5 and -7 at LDCM launch. After launch, the OLI and TIRS instruments will undergo extensive calibration and characterization during commissioning and through operations phases.

Dave Hair [USGS—*LDCM Project Manager*] and **Doug Daniels** [The Aerospace Corporation] reported on LDCM ground systems activities. Ground Readiness Tests (GRTs) are underway; significant progress has been made in verifying critical mission operations functionality. They discussed progress on the Ground Network Element (GNE), Collection Activity Planning Element (CAPE), Data Processing and Archive Element (DPAS), and International Cooperator (IC) network.

Landsat 5 and 7 Status

Kristi Kline [USGS—*Landsat Project Manager*] and **Rachel Headley** [USGS—*Landsat Project*] provided status on the Landsat-5 and -7 spacecrafts, archive operations, and the Landsat Global Archive Consolidation (LGAC). Landsat-7 continues operating with no significant new issues. Landsat-5 also continues to collect data, but issues with the Traveling Wave Tube Amplifier require persistent monitoring. Over 170,000 Multi-

spectral Scanner (MSS) scenes have been recovered and added to the archive. Distribution statistics show strong and increasing demand for Landsat scenes since the data became free. The archive is migrating to modern storage media, which will increase processing throughput in the future. LGAC has repatriated nearly 300,000 Landsat scenes from international stations to the U.S. archive to date.

Other Landsat-related Activities

Natalie Sexton [USGS Fort Collins Science Center] reported that results of the recent USGS Landsat survey are now available as a publication titled *The Users, Uses, and Value of Landsat and Other Moderate-Resolution Satellite Imagery in the United States – Executive Report*. The publication is available at: *pubs.usgs.gov/of/2011/1031/*.

Jeannie Allen [Sigma Space/GSFC] reviewed several aspects of NASA's Education and Public Engagement approach. These included a Landsat website redesign, establishing Landsat on *Facebook* and *Twitter*, developing new brochures, describing ongoing events and educational partnerships, and the Landsat Legacy Project[2].

Noel Gorelick [Google] spoke about Landsat data and recent progress on the *Google Earth* Engine prototype.

Peter Becker [Esri] spoke about Landsat data and recent *ArcGIS* [3] advances in raster image handling.

Sentinel-2 Discussion

Because European Space Agency representatives could not attend this meeting, **Alan Belward** [European Community Joint Research Centre—*Landsat Science Team Member*] gave a brief update on the status of Sentinel-2. The first Sentinel-2 launch is tentatively planned for 2013; it will include an optical instrument with a 13-channel multispectral imager with 10-m, 20-m, and 60-m resolution. The tentative data policy, subject to European Union approval, is to provide Sentinel-2 data for scientific purposes at no cost. The Science Team discussed areas of synergy between LDCM and Sentinel-2, including instrument cross-calibration, consistent product specifications, and coordinated acquisition planning.

LOGICAL - A Landsat Augmentation Concept

Darrel Williams [Global Science and Technology, Inc.—*Landsat Science Team Member*] described his Land Observations Globally in a Cost-effective Augmentation of Landsat (LOGICAL) concept. The LOGICAL goal is to develop a low-cost strategy for improving the frequency of Landsat-type observations. It is based on augmenting "gold standard" Landsat observations with those obtained from small satellites with lower-cost instruments that image a wider field of view. The result would be observations that, when cross-calibrated with Landsat measurements, provide multi-spectral imagery of sufficient quality to be used with Landsat for more robust global monitoring.

Science Presentations

Prasad Thenkabail [USGS] presented a knowledge-based automated cropland mapping algorithm. The algorithm is based on cropping zone, and depends on an accurate knowledge base and multiple data sources including Landsat, Moderate Resolution Imaging Spectroradiometer (MODIS), and digital elevation variables. Thenkabail demonstrated results for Tajikistan. The algorithm derived an overall accuracy of 98.9% for mapping three classes: irrigated areas, rain-fed areas, and all other land cover and land use classes.

Dirk Pflugmacher [Oregon State University] described a study of annual forest disturbance history from 1972–2010. The study leveraged recent improvements in MSS radiometry to extend earlier analyses based on Thematic Mapper (TM) data that extend back to 1972. A good correlation between MSS and TM indices exists during overlapping time periods, enabling inter-calibration of the datasets. The analysis captured both abrupt and slow disturbance in the long-time series.

Robert Kennedy [Oregon State University] spoke about moving towards attribution of change agents using Landsat time series information. While simplified pixel-level temporal trajectories can detect vegetation changes, the attribution of change agents to the trajectories was conceptualized as a fundamentally patch-based problem. Kennedy presented a methodological framework to: 1) generate patches from the pixel-based information; 2) utilize patch metrics and process knowledge to aid attribution; and 3) validate the results.

Mike Wulder [Canadian Forest Service] presented the results of two research projects that used Landsat time series imagery. The first project used time series data to identify salvage harvesting activity within recently burned sites. The second project focused on the productive capacity of boreal forest ecosystems after disturbance. Wulder found that both harvested and burned areas were recovering and had gross primary productivity similar to undisturbed samples.

[2] The Landsat Legacy Project conducts oral history interviews with members of the Landsat alumni. Together with an ongoing literature search, the project is unearthing interesting and useful information about the development and maintenance of the Landsat program over its 30+ year history.

[3] ArcGIS is a suite consisting of a group of geographic information system (GIS) software products produced by Esri. *www.esri.com/software/arcgis/index.html*

Landsat Products Development

Curtis Woodcock reviewed the impetus and focus for developing an expanded suite of Landsat products. He stated that expanding the range of successfully implemented products would significantly enhance the impact and relevance of the Landsat Program. Initial efforts should focus on enabling products such as surface reflectance, surface temperature, and cloud masks. Later, the focus can shift to higher-level science products such as land cover, land cover change, leaf area index, and albedo.

Jeff Masek [GSFC—*Landsat Project Scientist*] underscored these points when he summarized outcomes of the Landsat Science Team November 2010 products workshop, held in Boston, MA.

John Dwyer followed up with a discussion of USGS plans for Landsat science products. The initial USGS priorities dovetailed with Science Team recommendations, including surface reflectance, surface temperature, land cover, and leaf area index. **Tom Loveland** provided details of the global land cover strategy that includes quantifying annual land cover components (e.g., percent trees, shrubs, herbs, water, and barren), and periodic land cover type maps.

John Schott [Rochester Institute of Technology] described progress in developing a land surface temperature product for Landsat, with the goal of delivering the methodology and software to USGS for implementation. Currently, the approach is being defined and tested for North America. In year two, the algorithms will be refined, extended globally, and evaluated. After refining and validating the global algorithms, the final tools will be delivered to USGS.

Chengquan Huang [University of Maryland College Park] presented the use of MODIS data to assess global Landsat surface reflectance products. Huang showed that operational quality assessments of Landsat surface reflectance products were feasible during the MODIS era. A suite of tools has been developed and is available for performing automated quality checks. For the post-MODIS era, Visible Infrared Imager Radiometer Suite (VIIRS) data might be used in replacement.

Future Meetings

The next meeting of the Landsat Science Team will be held at the USGS Earth Resources Observation and Science Center (EROS) near Sioux Falls, SD, from August 16-18, 2011. The meeting will emphasize the science accomplishments achieved during the five-year term of this Landsat Science Team. ■

AMSR-E Level-2A Brightness Temperatures Now Available Through LANCE

The Advanced Microwave Scanning Radiometer for EOS (AMSR-E) Science Investigator-led Processing System (SIPS) and Global Hydrology Resource Center Distributed Active Archive Center (GHRC DAAC) are pleased to announce that we have integrated a new Level-2A (L2A) Brightness Temperature algorithm into our Land Atmosphere Near-real-time Capability for EOS (LANCE) processing systems. Developed at Remote System Systems (RSS), these much improved *Version 11* brightness temperatures, as well as the corresponding Level-2B (L2B) and Level 3 (L3) daily derived products, are available for FTP (registration required) from our LANCE servers at: *ftp://lance1.nsstc.nasa.gov/ops/* and *ftp://lance2.itsc.uah.edu/ops/*.

This new Near-Real-Time (NRT) L2A algorithm is comparable to the *Version 11* L2A algorithm currently used to process standard data products at the AMSR-E SIPS. We are seeing only very small differences (less than 1 K in most cases) in the data produced by the new NRT *Version 11* algorithm compared to the *Version 11* standard data product algorithm. The primary difference between the new *Version 11* NRT L2A code and the L2A science code used in the SIPS for generating research-quality L2A brightness temperatures is that the NRT algorithm uses static rather than dynamic calibration.

We will continue to evaluate the *Version 11* NRT data during the next year and document our findings on the AMSR-E SIPS LANCE website at: *lance.nsstc.nasa.gov/*.

More information about LANCE AMSR-E near real-time data and other LANCE elements [including the Advanced Infrared Sounder (AIRS), Ozone Monitoring Instrument (OMI), Microwave Limb Sounder (MLS), and Moderate Resolution Imaging Spectroradiometer (MODIS)] are available at: *lance.nasa.gov/*.