# Summary of 2018 ASTER Science Team Meeting

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## Introduction and Overview

The forty-ninth U.S.–Japan meeting of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team was held at Japan Space System's offices in Tokyo, Japan, June 4-6, 2018. The meeting attracted over 40 participants and offered 5 working-group (WG) sessions. From the U.S., participants were from NASA's Goddard Space Flight Center (GSFC), NASA/Jet Propulsion Laboratory (JPL), University of Pittsburgh (UP), University of Arizona (UA), University of Washington (UW), University of Hawaii (UH), and U.S. Geological Survey (USGS). From Japan, participants were from Japan Space Systems (JSS), Ibaraki University (IU), Nagoya University (NU), University of Tokyo (UT), National Institute of Advanced Industrial Science and Technology (AIST), Geological Survey of Japan (GSJ), Sensor Information Laboratory Corp. (SILC), National Institute for Environmental Studies (NIES), and Japan Aerospace Exploration Agency (JAXA). The main goals of the meeting were to:

- Discuss the status of the ASTER instrument and Terra spacecraft;
- review the August 2017 Terra spacecraft's Lunar Deep Space calibration maneuver;
- discuss the release of Version 3 of the Global Digital Elevation Model (GDEM3); and
- provide updates on image acquisition scheduling for the following year.

## Opening Plenary Session

The meeting opened with greetings from the Japan and U.S. Team Leaders, **Y. Yamaguchi** [NU] and **M. Abrams** [JPL].

**M. Abrams** reported on the start of negotiations between Japan's Ministry of Economy, Trade, and Industry (METI) and NASA for the continuation of the ASTER project beyond October 2019, when the current agreement expires. NASA has recently announced four new members of the U.S. ASTER Science Team: V. Realmuto [JPL]; D. Pieri [JPL]; M. Ramsey [UP]; and R. Wright [UH]. All of the new Team members are volcanologists. Abrams also highlighted ASTER's participation in the Hawaii volcano campaign,[1] where NASA brought its ER-2 aircraft, equipped with four imaging sensors.[2]

**M. Abrams** then gave a report as proxy for **W. Turner** [NASA HQ—*Program Scientist for Biological Diversity* and *Program Manager for Ecological Forecasting*] in which he described developments from the Second (2017-2027) Earth Science Decadal Survey.[3] In early 2019, NASA will decide which of its field centers

[1] This campaign also involved a study of Hawaii's coral reefs. The campaign provided precursor data for NASA's proposed Hyperspectral Infrared Imager (HyspIRI) satellite mission concept to study Earth ecosystems and natural hazards such as volcanoes, wildfires, and drought.

[2] These instruments include the: Advanced Visible–Infrared Imaging Spectrometer (AVIRIS); MODIS–ASTER Airborne Simulator (MASTER); Hyperspectral Thermal Emission Spectrometer (HyTES); and Portable Remote Imaging Spectrometer (PRISM).

[3] The full text of the Second (2017–2027) Earth Science Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observing from Space* (2018), can be downloaded from *https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth*.

Attendees at the 2018 ASTER Science Team Meeting held in Tokyo, Japan. **Photo credit**: T. Tachikawa/JSS will be responsible for the Surface Biology and Geology (SBG) mission/observing system.[4] SBG builds on the demonstrated capabilities of ASTER's multispectral thermal infrared (TIR) channels, and the ten-year Hyperspectral Infrared Imager (HyspIRI) mission study.[5]

**J. Hendrickson** [GSFC] then discussed the status of the Terra spacecraft, on which all systems continue to operate nominally. There is enough fuel to maintain Mean Local Time (MLT) of the orbit equatorial crossing and the orbit altitude until 2022. After exiting the Morning Constellation orbit at that time, Terra is expected to continue operating at a lower altitude and drifting MLT until 2026. Data capture continues at nearly 100%.

**T. Maiersperger** [USGS] discussed NASA's Land Processes Distributed Active Archive Center's (LPDAAC) plan to release GDEM V3. Higher-level data processing software will soon offer users the choice of output created from either the earlier Level 1B input, or the newer Level 1T (geocoded and orthorectified) input. He also noted that the GDEM continues to be the most frequently requested ASTER product.

## Working Group Meeting Discussions

The bulk of the meeting was dedicated to deliberations of various working groups. Each subsection below summarizes the purpose of each working group, and then gives highlights from the discussion.

### *Radiometric Calibration Working Group*

The Radiometric Calibration WG is responsible for monitoring the ASTER instruments to understand and characterize their responses to scenes being observed. The WG noted that the instrument response is changing smoothly with time. They determined updated calibration coefficients to maintain calibration of the data. Data from the onboard visible/near infrared (VNIR) calibration lamps and onboard TIR blackbody are combined with *in situ* field validation campaigns to monitor the instruments' performances. The individual reports in this subsection delve into the details of specific calibration activities connected to Terra in general, and ASTER in particular.[6]

**M. Kikuchi** [JSS] reported that Terra's August 2017 Deep Space Lunar Calibration Maneuver[7] (illustrated in **Figure 1**) has been helpful for ASTER image processing. Since the maneuver was completed, there has been an improvement of the sensitivity correction parameter (verified using both onboard and vicarious calibrations), making it possible to continue to produce high quality products. Based on these results, scientists hope to create a standard database on optical sensors calibration and verification that can be used to and contribute to the validation of data obtained by small satellites, or other instruments that do not have onboard calibration capabilities.

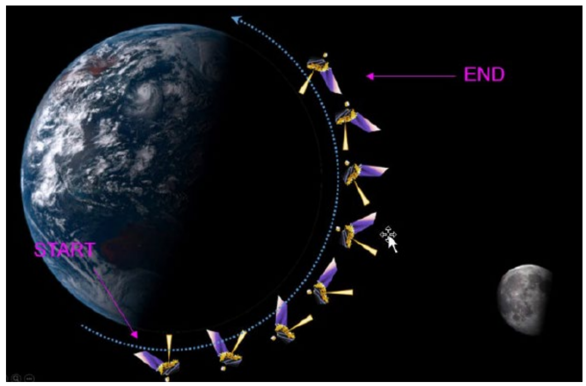


**Figure 1**. This diagram shows the progression of Terra's Deep Space Lunar Calibration Maneuver executed in August 2017, when Terra did a 360° pitch-over maneuver (essentially, a "backflip") to observe the moon. **Image credit:** T. Kouyama

**T. Kouyama** [JSS] presented his analysis of the August 2017 Deep Space Lunar Calibration Maneuver. His analysis confirms the responsivity change of the VNIR channels, and validates the current calibration method for Bands 1 and 2, which is based on a combination of vicarious calibration, cross-comparison with other instruments, and interband comparisons. Calibration of Band 3N is based on onboard calibration lamps, which are known to have degraded.

**S. Tsuchida** [AIST] discussed vicarious calibration of the ASTER instrument using results from field campaigns at Railroad Valley, NV. The observed trend in VNIR radiometric calibration coefficients emerging from such vicarious calibration experiments appears

[4] In a departure from its predecessor, the Second Earth Science Decadal survey emphasizes types of observations as opposed to specific missions allowing for more flexibility in implementing the recommendations of the survey. It does however identity five *Designated Observables* for mandatory acquisition: Aerosols; Clouds, Convection, and Precipitation; Mass Change; Surface Biology and Geology; and Surface Deformation and Change.

[5] HyspIRI was identified as a Tier 2 priority mission in the First Earth Science Decadal Survey, which can be downloaded without cost from *https://www.nap.edu/catalog/11820/earth-science-and-applications-from-space-national-imperatives-for-the*.

[6] This article discusses two common techniques used for on-orbit calibration. *Vicarious calibration* is when a sensor makes use of "invariant" natural targets on Earth (e.g., deserts, forests, snow covered areas) for post-launch assessments of stability; *onboard calibration* makes uses of lamps and reference standards onboard the spacecraft itself.

[7] To learn more about this maneuver, see "Terra Flips for Science" in the September–October 2017 issue of *The Earth Observer* [**Volume 29**, **Issue 5**, pp. 18-19]—*https://eospso.gsfc.nasa.gov/sites/default/files/eo_pdfs/Sept_Oct_%202017_color.pdf#page=18*.

stable. Intercomparisons with Landsat and MODIS[8] were performed based on synchronous data.

**H. Tonooka** [IU] discussed the results of field experiments carried out at Alkali Lake, NV, and Lake Kasumigaura, Japan. The results indicate that the onboard blackbody calibrator for the TIR channels is keeping the design accuracy of 1 K in the temperature range of 0 to 36 °C (32 to 97 °F). Two additional campaigns in Nevada and two campaigns at Lake Kasumigaura are planned for the coming year. The possibility of a campaign at a frozen lake (location to be determined) is also being investigated.

**S. Hook** [JPL] discussed the Lake Tahoe and Salton Sea (California) automated validation sites used to assess ASTER's radiometric accuracy. The Lake Tahoe site was established in 1999 and the Salton Sea site in 2008. Both the daytime and nighttime validations have slightly negative bias. Results indicate ASTER meets preflight specification and has operated within preflight specification for the duration of the Terra mission. Results obtained during 2017–2018 show that ASTER TIR performance was within range of recent years–i.e., it shows the same general pattern during 2017–2018 as it did the previous couple of years.

**K. Thome** [GSFC] described the Radiometric Calibration Network (RadCalNet),[9] which consists of multiple automated *in situ* measurement sites operated independently but using the same methodology and processing chain with known and documented uncertainties. RadCalNet products include top-of-atmosphere reflectance. RadCalNet sites include Railroad Valley Playa, NV (RadCaTS), and La Crau, France (Gobabeb). Data will be freely available to anyone that registers at the RadCalNet portal. Preliminary analysis shows good agreement between ASTER L1T data and RadCalNet observations obtained at both Railroad Valley and La Crau. More data from operational sites need to be evaluated.

[8] MODIS stands for Moderate Resolution Imaging Spectroradiometer, which flies on NASA's Terra and Aqua platforms.
[9] Learn more at *https://www.radcalnet.org/#*.

*Applications Working Group*

The Applications WG provides a platform for team members to present and discuss their science research activities using ASTER data. Its sessions usually span two days of the meetings. The majority of work is being done in the disciplines of geology, oceanography, and ecology.

**K. Hirose** [JSS] reported on a study to monitor coastal erosion on the island of Java, Indonesia. Using a time history of ASTER and Landsat data extending back more than 20 years, Hirose found that coastal erosion had two main causes: subsidence leading to seawater incursion; and mangrove deforestation due to conversion to aquaculture, rice cultivation, development of oil palm plantations, and urban development, all of which cause destabilization of the coastal areas.

**R. Wright** [UH] presented his work to integrate ASTER with MODIS/VIIRS[10] for quantifying volcanic unrest. He illustrated an improved hot spot detection algorithm for MODVOLC.[11] Using Google Earth Engine, Wright will gap-fill the global high-temporal-resolution MODIS/VIIRS record with high-spatial- but low-temporal-resolution ASTER and Landsat data for low-intensity activity—as illustrated in **Figure 2**.[12] Statistical analysis of the 20-year record will improve detection of eruption precursors as a function of the idiosyncratic behavior of individual volcanoes.

**M. Abrams** spoke on behalf of **J. Kargel** [UA], whose presentation highlighted glaciological applications of ASTER data. In the previous few months, many articles, making major use of ASTER data, appeared in

[10] VIIRS stands for Visible Infrared Imaging Radiometer Suite, which flies on the Suomi National Polar-orbiting Partnership (NPP) mission and on the Joint Polar Satellite System-1, which is now referred to as NOAA-20.
[11] MODVOLC is a University of Hawaii operational program to provide near-real-time satellite monitoring of global volcanism using MODIS. For more information, visit *http://modis.higp.hawaii.edu*.
[12] This figure has been published in *Remote Sensing of Environment*, online at *https://www.higp.hawaii.edu/~wright/rse131.pdf*.

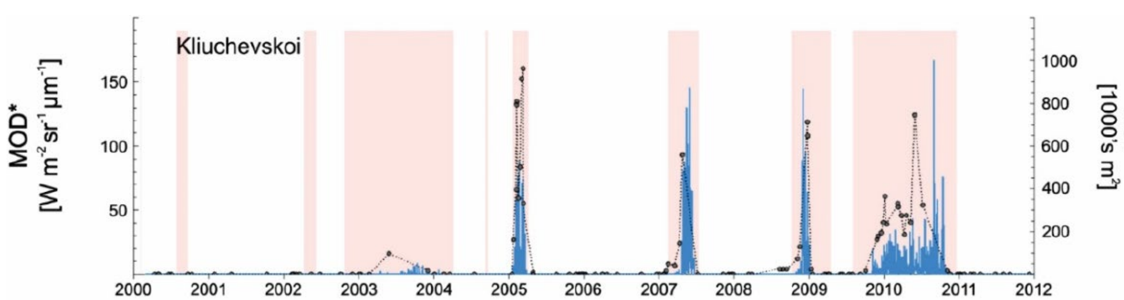


**Figure 2**. The blue curve shows the spectral radiances emitted from the lava flows and the summit crater of Kliuchevskoi Volcano, Kamchatka, Russia, for the period 2000-2012, as recorded by low-spatial-resolution [1-km (~0.6-mi)] MODIS data (y-axis labeled MOD on left side). Black dots show the same activity as recorded by the higher-resolution [(90-m (~295-ft)] ASTER sensor (y-axis labeled AST on right side; units are thousands of square meters of elevated temperature), using a metric that reconciles the different wavelengths and spatial resolutions of these two sensors, allowing them to be used side-by-side to quantify volcanic activity at high- and low-spatial resolution. **Image credit**: Murphy *et al.*

several journals (e.g., *The Cryosphere*, *Nature Geoscience*, and *Water*). Scene digital elevation models (DEMs) were of critical importance to determining glacier volumes as a function of time. ASTER has offered this unique capability for nearly 20 years. The article that was published in *The Cryosphere* made use of over 50,000 ASTER scene-based DEMs to calculate the mass balance of glaciers in the high mountains of Asia.

**Y. Ninomiya** [GSJ] discussed his method for mapping mineralogical indices using ASTER TIR data at both global and regional and local scales. He created mineralogical indices to detect the occurrence of carbonates, quartz, and mafic minerals.

*Operations and Mission Planning Working Group*

The Operations and Mission Planning WG oversees all scheduling of ASTER instruments. Because ASTER acquires data only on demand, a complex scheduling algorithm has been developed to assemble daily schedules for which scenes will be acquired. Various mapping programs run simultaneously, such as the global mapping program that operates in the background when no higher-priority acquisitions are scheduled.

**M. Fujita** [JSS] presented updates of the observation status for ASTER's mapping programs and data acquisition. The Global Mapping-7 program has successfully acquired about 71% of the programmed scenes with 20% or less cloud cover. The group recommended starting Global Mapping-8 in October 2018. The currently running Nighttime TIR Global Mapping program has achieved a 92% success rate. Based on recommendations from the Temperature-Emissivity Separation Working Group (discussions summarized below), a new mapping will start in June 2018.[13] The Underserved Area program (an effort to acquire images over persistently cloudy areas) will be restarted sometime in the summer of 2018. The Glacier Monitoring Program will continue for at least one more year, but the program will be evaluated to assess its viability beyond that. The Volcano Monitoring Program (which provides frequent day and night coverage of 1500 active volcanoes) will continue for the next few years. The Remote Island Program (which obtains single scenes over isolated mid-ocean targets) will restart in the summer of 2018. Fujita also summarized those observations that fall under the rubric of urgent observations (which include field campaigns, volcano monitoring, and natural hazards). About 2% of the requests for Urgent Observations failed to be processed. Fujita went through the details of each individual failed request. In general, the failures occurred because the requests were received after the allowed scheduling window had closed.

**H. Tonooka** [IU] provided an update of the ASTER cloud reassessment. The MODIS35 cloud assessment product had been updated from Version 6.0 to 6.1. The ASTER cloud assessment relies on this product, so Tonooka has updated the ASTER assessment as of January 2018. His evaluation indicated that 1% of ASTER scenes show a greater than 25% discrepancy in cloud coverage between the old product and the new one.

*Level 1-DEM Working Group*

The Level 1-DEM WG is responsible for monitoring the performance of the Level 1 processing software, monitoring the geometric performance of the VNIR and TIR instruments, and overseeing the GDEM product.

**T. Maiersperger** [USGS] discussed the geolocation error distribution of the Level 1T product, using the Landsat assessment system to conduct his analysis. Geometric accuracy was found to be consistent over time, with no anomalous behavior noted in the data acquired during the past year. As reported at previous ASTER Science Team Meetings, the scenes with the largest errors are in the cloudy tropics.

**M. Abrams** provided an overview of the soon-to-be-released ASTER Water Body Dataset (ASTWBD). This is a unique, global, raster data set that identifies waterbodies and separates them into lakes, rivers, and ocean categories. In addition, elevations are provided for each water body, including decreasing elevations for rivers from their start to their end in lakes or ocean. He noted that a user guide has been completed, and that the ASTWBD will be released and distributed jointly by the LPDAAC and JSS at the same time as GDEM V3 is released.

**M. Abrams** went on to provide some details about GDEM V3. This is the final update to the GDEM that the ASTER Science Team plans to make; it was created by editing of GDEM3 acquired from SILC in Japan. Robert Crippen [JPL] reprocessed GDEM3 to remove remaining artifacts, and to fill voids with other data sets. Residual problems where clouds occurred, where errors introduced by filling voids with a low-quality DEM, and from other anomalies have been identified and corrected. The result is a virtually error-free dataset. A draft user guide was shown and distributed to the Japan ASTER Science Team for editing. THE GDEM V3 will be jointly released and distributed by JSS and LPDAAC in the summer of 2018.

*Temperature/Emissivity Separation Working Group*

The Temperature-Emissivity Separation (TES) WG is responsible for monitoring and maintaining the algorithms that produce the calibrated temperature and

[13] **UPDATE**: The new mapping began in June 2018 as planned.

emissivity ASTER products from the Level 1 TIR data. The group monitors the acquisition program that obtains global coverage of Earth's entire land surface. A nighttime global time-series is obtained by repeating the acquisition scheduling on a regular basis (i.e., restarting every few years).

**H. Tonooka** presented an update on the Satellite-based Lake and Reservoir Temperature Database in Japan (SatLARTD-J). The database now covers 1005 inland bodies of water in Japan, and uses ASTER TIR data as inputs. The radiance data are recalibrated, corrected for stray light, corrected for atmospheric water vapor, and input into the TES algorithm; ASTER-derived water temperatures are the output. Temperature retrieval errors are generally about 1 K.

**H. Tonooka** also discussed his evaluation of MODIS thermal anomaly products using ASTER images. He investigated the influence of the subpixel position of a hotspot in the MODIS product using MODIS images accurately simulated from simultaneously acquired ASTER images. He showed that a thermal anomaly could not be detected by MODIS if it was located at the boundary between pixels.

**S. Hook** discussed validation of ASTER TES algorithm applied to data from the Lake Tahoe and Salton Sea calibration sites in Nevada. He compared the ASTER standard temperature product with temperature measurements made in situ with highly accurate radiometers, and used a radiative transfer code to propagate the surface radiance through the atmosphere and to the satellite. The results agree to well within algorithm requirements of 1 K.

The TES Working Group has evaluated the success of the Thermal Global Mapping (TGM) acquisition program. Version 9 of the TGM (TGM-9 has achieved over 92% success. The group recommended that TGM-10 should be started as soon as possible, with the same priorities and areas as TGM-9.

**Closing Plenary Session: Meeting Summary**

The chairpersons of each of the WG presented summaries of presentations and subsequent discussions for each of their sessions, which led to further discussion or relevant information by the team as a whole. The overall "sense of the Team" is that the Terra platform in general, and the ASTER instruments specifically, are performing nominally—with no significant change since the preceding 2017 team meeting. Continuing discussions about the August 2017 Deep Space Lunar Calibration Maneuver verified that the maneuver was completely successful; results will be incorporated in the next update of radiometric calibration coefficients. The GDEM V3 will be released in the summer of 2018, pending final correction of the few remaining artifacts. The next meeting will be held June 10-12, 2019, at the same venue in Tokyo. ■

Acknowledgment

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