Commercial Satellite Data Acquisition Program

ICEYE U.S. Principal Investigator Evaluation Summary

Goddard Space Flight Center
Greenbelt, MD

Commercial Satellite Data Acquisition Program ICEYE U.S. Principal Investigator Evaluation Summary

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Preface

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Abstract

The evaluation summarized in this report was conducted by Principal Investigators (PIs) funded by NASA's Commercial Satellite Data Acquisition (CSDA) Program. The purpose of evaluation is to determine the utility of the ICEYE U.S. data for NASA Earth science research and applications community. The results of the evaluation help to inform NASA program management on the value of the data and continued access to further augment NASA science.

Cover Art: Cover art is AI generated graphic using Microsoft Copilot Designer using term "commercial satellite constellation Earth observation across Atlantic AND Northern Hemisphere AND digital downlink"

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Table of Contents

List of Figures

List of Tables

Executive Summary

NASA's Earth Science Division (ESD) Commercial Satellite Data Acquisition (CSDA) program selected 14 principal investigators (PI), along with their teams, via a call for proposals under the NASA Research Opportunities in Space and Earth Science (ROSES) solicitation, to evaluate ICEYE U.S. (also referred to within as ICEYE) as part of the third CSDA on-ramp. ICEYE launches and manages a constellation of X-band synthetic aperture radar (SAR) instruments that provide high spatial resolution, frequent revisit, and reduced data delivery latency views of the Earth's surface. ICEYE launched their first satellite in January 2018. At the beginning of this evaluation ICEYE had 13 satellites on orbit and launched another 8 satellites during the evaluation period. During this CSDA evaluation the teams evaluated ICEYE data across a spectrum of Earth science disciplines, including Solid Earth, Cryosphere, Water Resources, Ecosystems and Natural Hazards.

The evaluation teams were provided access to the ICEYE archive of acquired scenes dating back to 2019. In addition to the archive data, CSDA teams were able to also task the ICEYE constellation for new acquisitions. This tasking allowed several of the teams, especially those studying natural hazards, to test the utility of ICEYE data in workflows that were more time sensitive. It also allowed evaluation teams the flexibility to acquire data in areas of interest that were experiencing change or responding to environmental conditions (i.e., harmful algal blooms).

The vendors participating in the CSDA Program are evaluated on the accessibility of vendor supplied data, accuracy and completeness of metadata, quality of user support services and documentation, usefulness of the data for advancing Earth system science research and applications, and the quality of vendor supplied data. Datasets purchased during the evaluations are archived by NASA, and after the evaluations have been completed, the evaluated data are made available to current and future government-funded researchers in accordance with the end user licensing agreement (EULA). The scientists evaluated the ICEYE data in the context of a variety of research topics (see Appendix).

The ICEYE evaluation kicked off with a first team meeting in March of 2023 and the team began formulating their data needs. Delivery of initial imagery products requested by the researchers began in June of 2023. This synthesis report distills and integrates the findings of evaluation research reports commissioned by NASA for the ICEYE evaluation. This report also includes recommendations that inform the way ahead for the program.

The report finds several strengths and weaknesses of these data for use in NASA Earth system science and applications investigations. In summary, the investigators found that the ICEYE data was useful and beneficial to many research and application areas. Investigators were extremely positive in their reviews of having access to high spatial resolution X-band SAR data and being able to task acquisitions for their specific work. The high temporal revisit and short latency windows were also positive. Evaluation teams were also very positive about ICEYE's customer support team that was highly responsive during the evaluation. It was noted that nearly all evaluation teams encountered geolocation issues with the data. These issues ranged from a few meters to tens of meters. It was also noted that the older archived data acquired by the earlier generation satellites in the constellation may have contributed to the larger geolocation errors. The evaluation team noted very few calibration errors during the evaluation, and the calibration errors that were identified were mostly constrained to imagery in Scan mode.

It is important to note that this evaluation did not include the ICEYE Ground Track Repeat (GTR) product, as it was not available when the contract was put in place for this evaluation. The GTR product allows for the acquisition of high-quality interferometry at 24-hour intervals. While evaluation teams were not able to task imaging in this mode, ICEYE did work with several evaluation teams that were hoping to evaluate the utility of ICEYE InSAR data by providing several previously acquired GTR data stacks at various locations around the world. The evaluation teams noted that it would be very beneficial to NASA and the CSDA Program to provide access to the ICEYE GTR products in the future.

1. Background

NASA's ESD formalized the CSDA program in 2020, following the successful Private-Sector Small Constellation Satellite Data Product Pilot that concluded that year. The objective of the CSDA program is to identify, evaluate, and acquire commercial remote sensing data that support NASA's Earth science research and application activities. When the Pilot transitioned into the sustained CSDA Program, on-ramping opportunities were released for new vendors with the idea of expanding and enlisting new commercial vendors as the industry expands with new candidates and capabilities. NASA's ESD recognizes the potential impact commercial satellite constellations may have in encouraging and enabling efficient approaches to advancing Earth system science and applications development for societal benefit.

In addition to the Pilot, NASA has conducted two evaluations since the Pilot, these included two vendors in On-Ramp 2 and four vendors in On-Ramp 3. ICEYE was part of On-ramp 3, and the three other vendors in this on-ramp were wrapping up their evaluation activities in a similar timeframe. See table 1 below.

NASA has moved into a sustainment phase for the vendors from the Pilot and On-Ramp 2 with data collected by these vendors made available to NASA and other government funded researchers, according to the EULAs. More information can be found on the CSDA web site, under Commercial Datasets. The table below shows the vendors that NASA has engaged with for commercial data evaluations thus far.

Table 1. CSDA Evaluation Activities.

Evaluation Effort	Vendor	Type	Report Delivery
Pilot	Maxar	Optical	Apr 2020
	Planet	Optical	
	Spire	Radio Occultation	
On-ramp 2	Airbus U.S.	SAR	Oct 2023
	BlackSky	Optical	Jun 2024
On-ramp 3	GHGSat	Optical	Aug 2024
	Capella	SAR	Dec 2024
	ICEYE U.S.	SAR	Dec 2024
	GeoOptics	Radio Occultation	Oct 2024
IDIQ On-ramp 1	Umbra	SAR	Aug 2025
	PlanetiQ	Radio Occultation	Aug 2025

The vendors were evaluated on the accessibility of data, accuracy and completeness of metadata and documentation, promptness and quality of user support services, and usefulness of the data for advancing Earth system science research and applications. NASA's CSDA Program license agreements were expanded following the Pilot to broaden the applicability of the commercial data for scientific applications across the U.S. Government. These license uplifts made the data more readily available across the government and improved both the value of these data and the opportunities for interagency collaboration. In addition, NASA has engaged in separate dedicated evaluation activities to assess the satellite data quality of each vendor.

Results from the Pilot and the On-ramp 2 evaluations are available from the CSDA website. The final summary reports for all the On-ramp 3 evaluations will also be published on the CSDA web site upon completion and review of the evaluation reports.

1.1 Blanket Purchase Agreement (BPA) On-Ramp 3

On-Ramp 3 evaluations were initiated in October 2022 with a request for information (RFI) seeking capability statements from the parties interested in providing data from spaceborne platforms for evaluation. To be responsive to the RFI, the commercial satellite vendors had to be U.S. companies with one or more spacecraft actively collecting data in low, medium, and geostationary Earth orbits with a minimum of near-continental-scale–coverage. Four vendors satisfied the RFI requirements and were asked to respond to a request for proposal. After review of the submitted proposals, NASA entered into a Blanket Purchase Agreement (BPA) with ICEYE U. S. in September 2022. The vendors evaluated during On-ramp 3 are listed in Table 2.

Table 2. The vendors and sensor information for On-ramp 3 evaluations (constellation numbers shown reflect status during the evaluation).

Vendor	Sensor Type	Temporal Coverage	Spatial Coverage	Satellites	Bands	Spatial Resolution
GHGSat	Optical	Jan 2021 - present	Global	10	1630 – 1675 nm	50 m
GeoOptics	GNSS-RO	Nov 2018 – Jan 2022	Global	0	L-Band	~100 km horizontal, ~100 m vertical
Capella Space	SAR	Jan 2021 - present	Global*	4-7	X - Band	0.5 -11.5 m
ICEYE US	SAR	Oct 2019 - present	Global	13-21	X - Band	1 - 15 m

*****_During the evaluation period, Capella lost its only polar orbiting satellite sensor, thus access to data over areas beyond 48.9 deg N/S were limited._

1.2 ICEYE Imaging Capabilities and Products Evaluated

ICEYE operated a constellation of 13-21 satellites during the CSDA evaluation period and the data evaluated were collected from satellite generations 2 and 3 in the ICEYE development cycle. These sensors acquire data in four imaging modes, Spot, Spot Extended Area, Strip, and Scan.

Table 3. Overview of the ICEYE modes and the characteristics of each.

Parameter	Strip	Spot	Spot Extended Area	Scan
Area coverage	30 km x 50 km	5 km x 5 km	15 km x 15 km	100 km x 100 km
Ground Resolution	3 m	1 m	1 m	15 m
Nominal Swath Width	30 km	5 km	15 km	100 km
Radar Beams Used	1	1	1	5
Nominal Product Length	50	5	15	100
Nominal Collection Duration	10 sec	10 sec	10 sec	15 sec

The CSDA evaluation teams had access to all four modes of data in the ICEYE archive and were able to task in each of the four modes described in Table 3. CSDA Evaluation teams submitted orders to the ICEYE US Customer Support team through a portable document format (PDF) order form and data were delivered via secure file transfer protocol (SFTP). At the time the evaluation began, ICEYE did not have an application programming interface (API) to utilize for searching and ordering data from the archives and scheduling new acquisitions. In May 2024, ICEYE did release an API, but evaluation teams were not able to test it due to the end of the 1-year CSDA evaluation period.

New tasking and archived ICEYE products were delivered with both the single look complex (SLC) and ground range detected (GRD) products available to the evaluation teams. Scan mode was delivered with only the GRD product. This flexibility allowed evaluation teams to utilize the format that was best for their research/application areas and workflows.

2. Evaluation Process and Criteria

NASA ESD selected 14 projects to perform the ICEYE evaluation. A subject matter expert (SME) team was also funded by CSDA to perform a quality assessment of the ICEYE data. The investigation teams are listed in Appendix A and are broken down there into broad application areas: natural hazards, volcanic and glacier science, water resources and ecosystems, InSAR analysis, and ocean science and sea ice.

The evaluation Principal Investigator (PI) teams were required to provide interim, midterm, and final surveys and reporting, and to attend monthly discussions to ensure they had sufficient information and data access to complete their evaluations.

2.1 Evaluation Criteria

The CSDA program provided evaluators the following categories for reporting on their findings from the ICEYE data evaluation for both the quality and utility of the data.

A. Access, Metadata and Support

I. Accessibility and format of vendor supplied data

The ease and efficiency with which data can be searched, discovered, and downloaded from vendor systems.

II. Accuracy and completeness of metadata

The accuracy and completeness of metadata that accompanies the imagery and data provided by the vendor.

III. Quality of support services, including documentation

The availability, responsiveness, and technical expertise required to answer PI inquiries.

B. Usefulness of the data for advancing Earth system science Research and Applications

The ability of vendor-supplied data to support Earth system science Research and Applications

C. Quality of Vendor Supplied data

The quality of data attributes, such as radiometric calibration, geolocation accuracy, and platform intercalibration.

2.2 Program Activities

The evaluation was facilitated by conducting periodic reviews and surveys, PI all-hands meetings, and monthly technical interchange meetings. The project timeline is depicted in Figure 1.

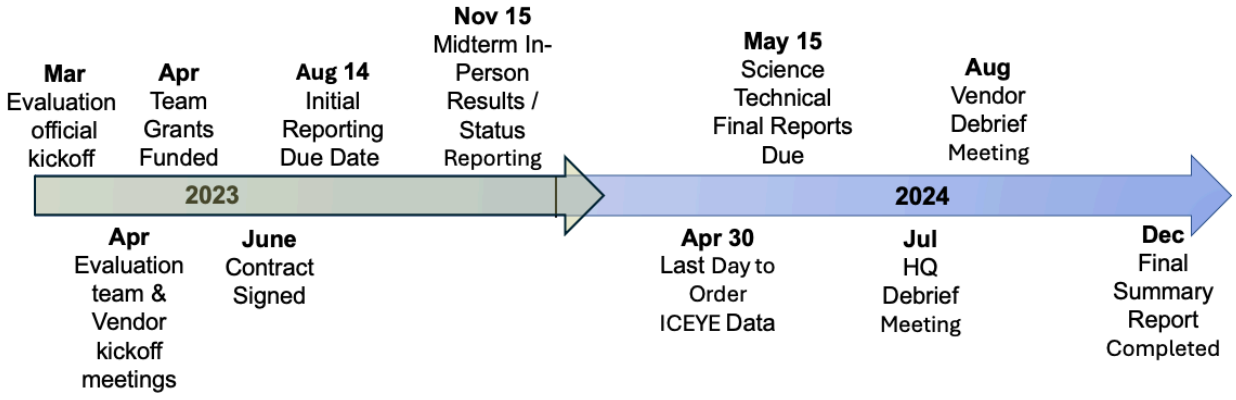

Figure 1. Timeline of Evaluation activities since awarding the purchase agreement. The evaluation began in June of 2023, when the teams began receiving ICEYE data.

2.3 Meetings, Periodic Reviews and Surveys

In addition to the team and vendor kick-off meetings, evaluation PIs were required to participate in periodic reviews and report on the usefulness of the data and current research progress. The PIs were asked to submit quad charts at three points during the evaluation, the first one shortly after gaining access to the data, the second at the evaluation midpoint, and lastly as part of their final submission. An in-person midterm meeting was held at the Goddard Space Flight Center that allowed the PIs to share their preliminary results and exchange information. All reports and surveys were synthesized in the creation of this final summary report.

2.4 Monthly Technical Interchange Meetings

Monthly conference calls were set up to facilitate technical interchange among the evaluation teams and with CSDA staff to help identify and resolve issues related to data access, quality, completeness, and processing. The teams were asked to identify issues and share information that might be relevant to other teams. The conference calls were set up as a means by which to ensure timely identification and prompt resolution of issues that might arise. These meetings also allowed the CSDA staff an opportunity to gather and relay any concerns that the team may have had to the vendor to accelerate resolution of any potential problems.

2.5 Community Engagement and Feedback

As the capabilities and number of commercial vendors grow, it is important to continuously monitor the development of new commercial technology, acquire relevant data to complement existing and future missions, and evaluate these data over time. The CSDA team continues to provide status updates, answer questions about data and data access, and provide information about future procurement opportunities for other commercial constellation providers at various science conferences and workshops. These community engagements serve as an open forum for dialogue between experts across the science data research community and help to showcase NASA's progress and commitment to building stronger ties to the commercial sector.

3. Key Findings

The key findings from this evaluation are organized into five general scientific areas that are aligned with corresponding Earth Science Division Programs. This evaluation was focused on assessing the utility of ICEYE data for advancing NASA's Research and Analysis and Earth Action focus areas. A summary of the different NASA programs and research areas evaluated by the PIs is presented below in Figure 2.

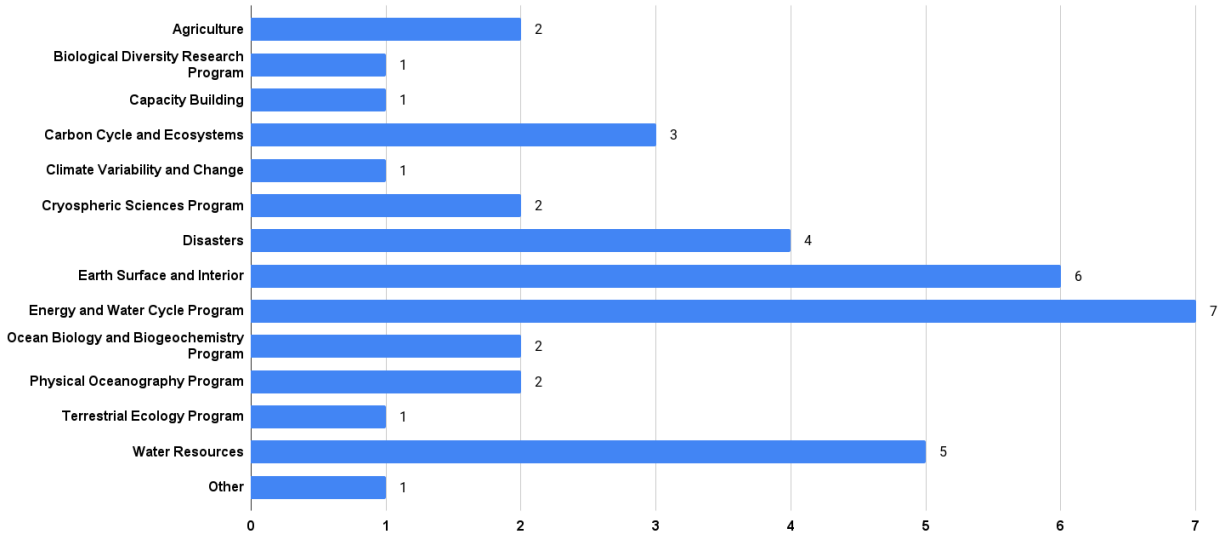

Figure 2. Evaluation research areas were varied, and some evaluations covered more than one research area.

The PIs and their evaluation teams had access to the ICEYE archive and had the opportunity to task ICEYE's constellation as well. A total of 55.5% of the data used during this 1-year evaluation were from the ICEYE archive, while the remaining 45.5% were from new taskings. The key findings address the evaluation criteria of the CSDA Program in the following sections.

3.1 Data Access, Customer Support, and Metadata

Data Access

Data access provided by ICEYE for this evaluation was overall very good, but many PIs provided recommendations on how ICEYE could improve access to data going forward. ICEYE provided the evaluation teams with keyhole markup language (KML) and geographic JavaScript Object Notation (GeoJSON) formatted files of their archive as a means to search for these data. The archive consisted of available acquisitions dating back to 2019. Several PIs noted this was a cumbersome methodology that was difficult to use. This also required ICEYE to regularly push updated KMLs and GeoJSONs of their archive, which was not done. The PIs and evaluation teams then had to generate and submit a list of desired archive images along with a PDF order form via email to the ICEYE Customer Support Team (CST). The CST would then upload the acquisitions to an SFTP location that the PIs could access. Most orders were fulfilled within 1-3 business days. It was noted by multiple PIs that this SFTP process had slow download speeds, with one PI specifically reporting a 2-3 Mb/s download connection. Many PIs suggested that an online, interactive viewer interface or access to an API tool would have been a welcome addition for ICEYE archive search and order.

The process to submit tasking requests for new data collections by the evaluation teams was also somewhat dated, although the ICEYE CST received praise from many PIs for their help during this process. The PIs submitted areas of interest (AOIs) and tasking information (imaging mode, frequency of imaging) for their tasking requests to the ICEYE CST by email. The CST would then return a feasibility study to the PI with available acquisitions and metadata in both Excel and KML

formats. The PI would then confirm the selected acquisitions with the CST. The PIs did note that the overall process of selecting and confirming specific acquisitions was fine but suggested that if the process was all online or through some sort of portal it would have been easier and more streamlined. It should be noted that ICEYE did release an API for both archive access and tasking in the spring of 2024. However, due to the release of the API late into the 1-year evaluation period, the evaluation teams were not able to utilize it.

One important caveat of this evaluation was that it did not include the ICEYE Ground Track Repeat (GTR) product, as it was not included when the contract was put in place for this evaluation. ICEYE describes their GTR product as daily ground track repeat, which allows for coherence and InSAR product generation. This did impact several PIs and their plans for this evaluation. These PIs did work extensively with the ICEYE CST to attempt to task and acquire non-GTR acquisitions that could be used for InSAR applications, with some success. The ICEYE CST also worked to provide the evaluation team with a list of GTR stacks in their archive that were available, and multiple PIs took advantage of this in their evaluations.

Customer Support

ICEYE provided very responsive and professional support during the evaluation with the CSDA Program PIs and evaluation teams. Thirteen of the PIs had very positive comments regarding their interactions with ICEYE and their customer service representatives, with one PI reporting they did not have a positive experience. Based on comments from the PI final reporting, it appears that most of the issues were with the nomenclature that ICEYE uses for their data and products, versus the nomenclature the evaluation teams were familiar with, as well as contractual limitations of certain products during this one-year evaluation period.

Metadata and Documentation

ICEYE provided metadata including acquisition information, sensor calibration, and instrument characteristics with all orders. Metadata provided by ICEYE was deemed sufficient and thorough by many of the PIs. Several PIs did recommend it would have been beneficial to have additional information about the perpendicular baselines and orbit tracks of the acquisition. This additional information would have helped the evaluation teams that had specific baseline requirements for their data analysis, especially those assessing InSAR applications.

ICEYE US provided the PIs and evaluation teams with extensive documentation of products, file formats, and metadata structure. Overall, documents provided by ICEYE were very helpful and well received. There were a few instances where the documentation did appear to be outdated, as there were references to product names that no longer existed or had been changed. It was suggested by several PIs that ICEYE revisit these documents and workflows and consider providing updates.

3.2 Data Utility for NASA Science

InSAR Analysis

The evaluation teams that focused on InSAR applications did find it difficult to participate in this evaluation with the GTR mode not being included. However, ICEYE provided several previously acquired InSAR time series that the PIs could evaluate. The evaluation teams found these time series useful to achieve their research goals, especially those evaluation teams focused on high density time series such as monitoring volcanoes and glacial changes such as those in Figure 3. The PIs would have liked to have had more detailed orbit and baseline information with the data, as well as access to Level 0 data for their algorithms and applications.

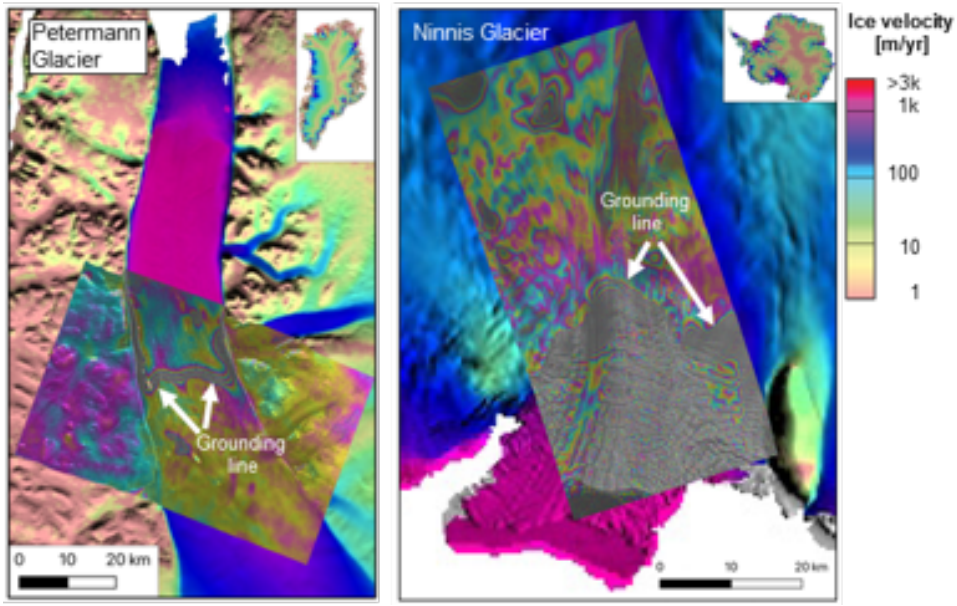

Figure 3. ICEYE Double difference interferograms overlaid on ice velocity maps. Grounding line is the upstream edge of dense fringe pattern. (B. Scheuchl/UC-Irvine)

Volcanic and Glacier Science

The evaluation teams that had a focus on volcanic and glacier science heavily utilized InSAR processing to evaluate ICEYE data for their specific applications. These PI evaluation teams had the same general difficulties of not being able to task the specific GTR product from ICEYE as well as the lack of orbit and baseline data. These evaluation teams were able to demonstrate the utility of the data for their research areas using previously collected or archived ICEYE GTR data. These PIs were able to demonstrate that ICEYE InSAR capable data could yield positive results for these application areas, especially with the potential for high frequency revisit times. The evaluation teams were very pleased with the high spatial resolution and low latency of product delivery. Archived product delivery was sometimes delayed (1-2 business days) because ICEYE reprocessed all acquisitions that were older than 3 months. Newly tasked acquisitions were generally delivered in ~ 6 hours, but delivery times improved to ~4 hours once ICEYE shifted to 24/7 customer support.

It should be noted that a couple of PIs in these application areas worked extensively with the ICEYE CST to attempt to demonstrate the utility of InSAR applications from regular tasking or non-GTR data (Figure 3). The teams worked to schedule nearly identical acquisition geometries

from the available tasking options. These efforts yielded mixed results, as the PIs were able to demonstrate that it could be done, however the InSAR products from this method were not as coherent as they could be with the GTR product.

Water Resources & Ecosystems

Water resources and ecosystems evaluations included investigations of soil moisture, harmful algal blooms (Figure 4), surface water dynamics, and various ecosystem AOIs around the globe. These teams overall had a favorable experience utilizing the ICEYE datasets. The evaluation teams were very positive about the ability to task acquisitions for their specific research areas. The PIs in these application and research areas encourage continued access to high resolution SAR data to supplement other Earth observations. Some PIs within this research area had concerns about the geolocation issues that were reported but expected that the utility of these data would improve if these issues were rectified.

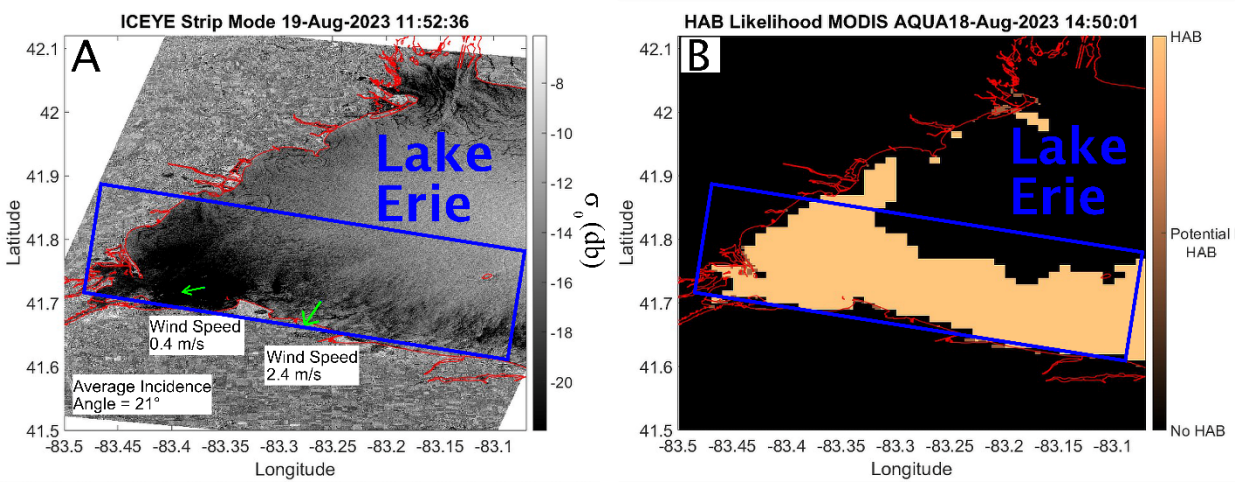

Figure 4. A) An ICEYE Strip SAR (σ0) returns over Lake Erie on August 19th, 2023. The green arrows represent the noted wind direction from buoys and the dark area in the blue box is a harmful algal bloom (HAB). B) A derived HAB map from August 18th, 2023, Aqua MODIS acquisition indicating HAB, Potential HAB, and No HAB conditions.

Natural Hazards

The PIs and evaluation teams with applications related to natural hazards and severe weather indicated that ICEYE data are relevant and useful to complement other datasets when evaluating the impacts from natural hazards and severe weather. The evaluation teams were able to resolve impacts to the land surface in greater detail as a result of the higher spatial resolution data. Evaluation teams were able to resolve landslides more accurately than freely available datasets and more clearly identify impacts to urban areas after severe weather (Figure 5), wildfires, and flooding. Evaluation teams also praised the ability to task acquisitions after various natural hazards in order to better understand their impacts, which could be extremely beneficial to various elements of NASA's Earth Action Program.

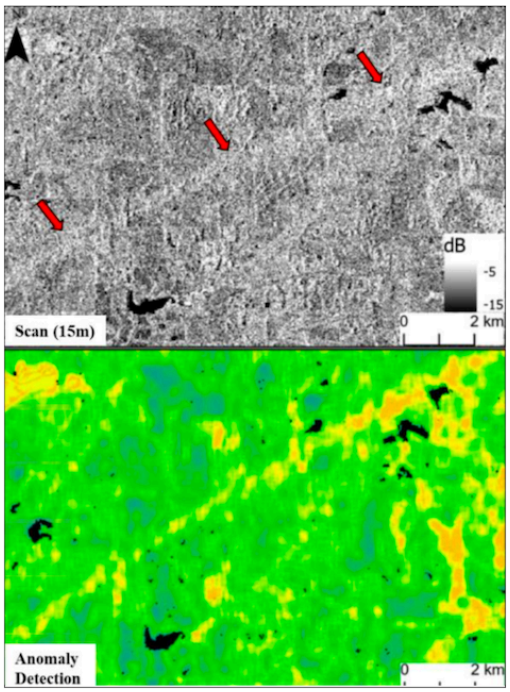

Figure 5. (Top) ICEYE scan image collected three days after an EF-3 tornado went through a densely forested area. (Bottom) anomaly detection results from the ICEYE image isolating the track from the surrounding background. (Molthan/MSFC)

Ocean Science & Sea Ice

The high spatial resolution of ICEYE data was found to be a positive aspect of the data for the evaluation of sea ice and object tracking in the open ocean. The evaluation teams were very enthusiastic about the ability to task acquisitions related to their individual projects, though each experienced some limitations for their individual applications. One evaluation team was specific in noting that geolocation errors reduced their confidence in using the data, especially when working with sea ice, as there are frequently times when no land masses are around for reference to help with geolocation correction. ICEYE's high spatial resolution was found to be extremely useful when attempting to identify and track large objects and oil slicks in the ocean, but its usefulness was more limited when considering smaller objects.

3.3 Data Quality Assessment

Geolocation

The biggest issue with the ICEYE data that was mentioned by nearly every evaluation team was the geolocation of the delivered products. This was especially prevalent when evaluation teams were using the GRD products. The magnitude of the geolocation errors varied amongst the evaluation teams from a few meters to tens of meters, depending on how the team processed the data and the location of the scene. Most evaluations that documented geolocation issues were using GRD products, which include a geocoding step using a topographic model. Therefore, the topographic errors compound the geolocation errors. These data were analyzed mostly with European Space Agency's (ESA) Sentinel Application Platform (SNAP) due to it's ease of use and open access policy.

Radiometric calibration

Two of the evaluation teams documented small calibration issues, with both teams noting the issues being more prevalent in Scan mode imagery.

For more details on the radiometric and geometric quality assessment, please refer to the CSDA ICEYE U.S. Quality Assessment report. A summary of the results from that report is presented in Figure 6.

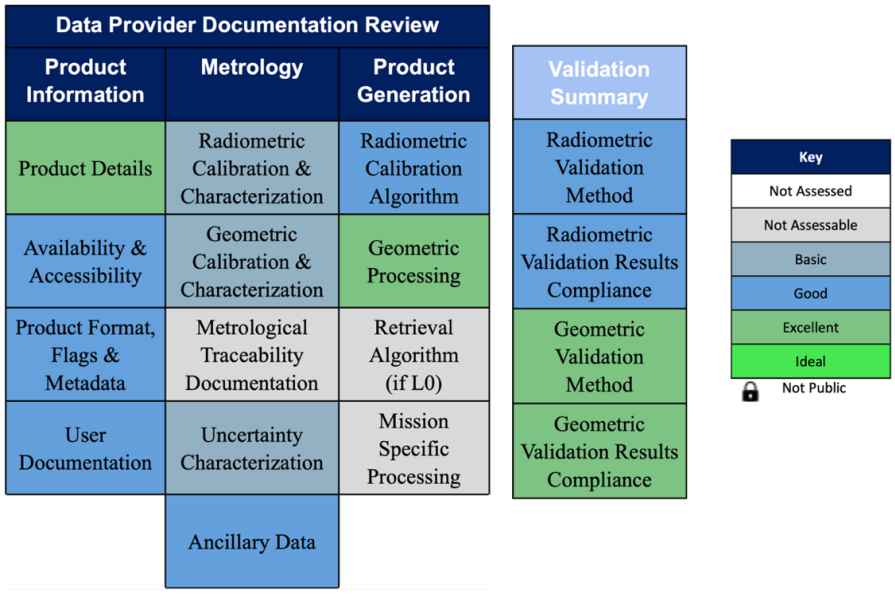

Figure 6. Summary Cal/Val Maturity Matrix from the ICEYE Synthetic Aperture Radar Quality Assessment.

4. Recommendations

The overall recommendation for ICEYE data following the one-year evaluation period was positive. A number of the NASA research and applications activities spanning multiple thematic areas were able to demonstrate a benefit of incorporating and utilizing ICEYE data. Research and application areas that did have some reservations about using ICEYE data, especially those requiring specific repeat data for InSAR, recommended that future agreements between NASA and ICEYE look for a viable option to provide GTR data. More than half of evaluation teams also stressed that if the geolocation errors were reduced and/or improvements were made to ICEYE's process for accessing the archive and data ordering, the strength of their recommendations would increase. The very high spatial resolution imagery provided by ICEYE and the ability for researchers to potentially task the ICEYE constellation for their areas of interest would complement NASA’s existing Earth observation capabilities.

5. Conclusions

A year-long evaluation of ICEYE data products was conducted by 14 PI teams. These 14 PIs represented five of the six NASA Earth Science Division Research and Analysis science focus areas as well as elements within the Earth Action Program. Thirteen of the evaluations demonstrated the usefulness of this commercial data for advancing scientific research and applications. The various evaluation teams did however note some limitations using ICEYE data such as geolocation errors, a limited archive, and the cumbersome data ordering process that was in place during the evaluation period. There were additional limitations noted by several evaluation teams regarding the GTR data, but those limitations were contractual and could be modified in the future. Overall, the utility of the evaluated data outweighed these limitations, especially since ICEYE did relay to the CSDA Program that they were working on improving some of these limitations prior to the end of the evaluation. This evaluation determined that ICEYE data would complement NASA's existing Earth observation capabilities.

Appendix A. Listing of Evaluation Research Projects

Project Title	PI & Institution
Natural Hazards	
Amplitude and Coherence Change Detection Applications for Assessing Damage from Severe Weather Events Using ICEYE X-band SAR Imagery	**Andrew Molthan,** NASA Marshall Space Flight Center
Evaluation of ICEYE data for landslide disaster response product generation	**Pukar Amatya**, University of Maryland Baltimore County
Volcanic & Glacier Science	
One-day repeat ICEYE InSAR of Mauna Loa Volcano	**Falk Amelung**, University of Miami
Feasibility study on 3-D surface deformation mapping for volcanic unrest and eruptions using ICEYE imagery	**MinJeong Jo**, University of Maryland Baltimore County
ICEYE constellation SAR data for cryosphere research – evaluation for CSDA	**Bernd Scheuchl**, University of California, Irvine
Water Resources & Ecosystems	
Assessment of geometric and radiometric quality of ICEYE data for soil moisture and waterbody mapping	**Seung-bum Kim**, Jet Propulsion Laboratory
Evaluating the capabilities of ICEYE radar imagery for high-resolution mapping of surface water dynamics	**Sarah Cooley**, University of Oregon
Evaluation of ICEYE SAR Imagery for Near Real-Time Monitoring of Harmful Algal Blooms	**Susan Janiszewski**, Michigan Tech Research Institute
Evaluation of X-band SAR data for Ecosystems and Snow applications	**Paul Siqueira**, University of Massachusetts Amherst

InSAR Analysis	
Evaluation of ICEYE imagery in areas with both deformation and agricultural signals	**Rowena Lohman**, Cornell University
Assessment of ICEYE Radar Constellation for Rapid Repeat, Fine Resolution InSAR Applications	**Howard Zebker,** Stanford University
Ocean Science and Sea Ice	
Evaluating the interactions of winds, waves, and thin ice types in coastal margins	**Mary Ruth Keller**, The Johns Hopkins University/Applied Physics Lab
ICEYE Products Utility Assessment for Open Ocean Research and Activities	**Nikolai Maximenko**, University of Hawaii
Evaluating ICEYE Space high-resolution data for Coastal Monitoring and Sustainable Water Management Practices	**Pietro Milillo**, University of Houston