GEO Geohazards Supersites and Natural Laboratories

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GROUP ON EARTH OBSERVATIONS

Committee on Earth Observation Satellites

Biennial report for Permanent Supersite/Natural Laboratory

Hawai'i Supersite

History	*https://geo-gsnl.org/supersites/permanent-supersites/hawaiian-volcanoes-supersite/*
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1. Abstract

In 2008, the Hawai`i Supersite was established to encourage collaborative research into volcanic processes on the Island of Hawai`i, and to aid with the assessment and mitigation of volcanic hazards to the local population. Made permanent in 2012, the Supersite now hosts a diverse array of data from a variety of sources. Comprehensive ground-based monitoring, conducted by the Hawaiian Volcano Observatory and collaborators, consists of deformation, seismic, gravity, gas emissions, camera observations, and geochemical analyses. Space-based data include thousands of Synthetic Aperture Radar (SAR) images provided by numerous national space agencies, as well as optical and thermal datasets that can be used to detect changes in topography and variations in thermal and gas emissions. Using these datasets, a variety of insights have been gained into how Hawaiian volcanoes work. For example, magma supply to Kīlauea appears to fluctuate on timescales of just a few years and has a direct impact on eruptive activity. Magma accumulation at Kīlauea can promote slip on nearby faults, triggering M4+ earthquakes. Magma storage and transport pathways were mapped at both Kīlauea and Mauna Loa volcanoes, providing a basis upon which to interpret past, present, and future monitoring data. In addition, Supersite data, particularly SAR, have been invaluable for operational monitoring of deformation and eruptive activity—critical information for understanding the evolving nature of volcanic hazards in Hawai`i. The wealth of available data has also facilitated the development of new methodologies for processing and analyzing SAR data, given the large number of images, availability of ground-based data for calibration/validation, and continuous volcanic activity against which to test new methods. This combination of data availability and volcanic activity have led to an extensive publication record, which demonstrates the success of the Supersites initiative. Recent research has focused on the 2018 flank eruption and summit collapse—the most significant activity to have occurred at Kīlauea in over 200 years and the best-observed caldera collapse sequence ever. Supersite datasets have facilitated exploration of, for example, the process of caldera collapse and the nature of magma-tectonic interactions. In addition, post-2018 datasets have been important for documenting resurgence of Kīlauea's magmatic system and understanding the nature of potential future hazards. Throughout Kīlauea's extraordinary activity, neighboring Mauna Loa has continued to inflate—a process that is well documented by InSAR. Insights from Supersite data have become invaluable to stakeholders on the Island of Hawai`i, and results provide exceptional fodder for scientific exploration into how volcanoes work.

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Scientists/science teams issues

No new science team members were added during this reporting period. Communication between the science teams and PoCs remains limited, and better coordination would be helpful, especially given the 2018 flank eruption and summit collapse, and the numerous resulting research efforts (which overlap to varying degrees in terms of subject matter and/or datasets). The COVID-19 pandemic has worsened this issue by restricting scientific meetings, where interactions between independent Supersite scientists and science teams would commonly take place, especially given the numerous Kīlauea-focused scientific sessions at conferences like the American Geophysical Union Fall Meeting.

Note that the list of Supersite users provided above is comprised of individuals who have requested access to CSK data, which are the only Supersite data that truly require PoC involvement. Other users who may access data via other means (for example, via their own PI agreements with space agencies) are not listed. It is difficult to define the scientists and science teams for the Hawaiʻi Supersite since there are so many people utilizing these data. This represents an ambiguity that GSNL may need to address at some point.

3. In situ data

Type of data	Data provider	How to access	Type of access
GPS	*USGS – HVO*	*UNAVCO*	*Unregistered public*
Seismic	*USGS – HVO*	*IRIS*	*Unregistered public*
Gas emissions	*USGS – HVO*	*Publications and DRs**	*Unregistered public*
Gravity	*USGS – HVO*	*Publications and DRs**	*Unregistered public*

Tilt	*USGS – HVO*	*Contact USGS – HVO***	*GSNL Scientists*
Camera	*USGS – HVO*	*Contact USGS – HVO***	*GSNL Scientists*
Strain	*USGS – HVO*	*Contact USGS – HVO***	*GSNL Scientists*

** Denotes data that are only released when published because significant data processing is necessary to achieve useable results. Peer review is required to assure the quality of the processed data. Since 2018, these data are made available via the USGS Science Base system.*

*** Denotes data that are not made publically available due to lack of a suitable archive but that can be obtained through collaboration with scientists at the USGS Hawaiian Volcano Observatory or, in some cases, via the USGS Science Base system.*

In situ data issues

A few datasets, like gas emissions and gravity, require significant post-processing. Because of the need for stringent quality control, such data are not made publicly available until they have been through the peer review process. When approved, these data are released via the USGS Science Base archive, where metadata are also available (https://www.sciencebase.gov/catalog/). Other datasets, including tilt, visual/thermal camera, and strain, are only available by contacting the data provider, since there are no established archives or agreed-upon formats for storing such data. The data may also be difficult to understand, requiring the provider to offer guidance on processing and interpretation. Data availability, however, is evolving, and the USGS has committed to making these data and explanatory metadata available as Science Base Data Releases. The cataloging of these datasets in Science Base is an ongoing process that we hope will be completed in the coming years. For GPS and seismic data, the UNAVCO and IRIS archives, respectively, continue to serve as the primary archives.

4. Satellite data

Type of data	Data provider	How to access	Type of access
ENVISAT	*ESA*	*http://eo-virtual-archive4.esa.int/?q=Hawaii*	*Registered public*
RADARSAT-1	*CSA*	*Uncertain**	*Registered public*
ALOS-1	*JAXA*	*Uncertain**	*Registered public*
TerraSAR-X	*DLR*	*Available after acceptance of PI proposal by DLR*	*GSNL scientists*
Cosmo-SkyMed	*ASI*	*POC requests access from ASI for individual users, data then accessible via UNAVCO*	*GSNL scientists*
RADARSAT-2	*CSA*	*POC requests access from CSA for individual users, data then accessible via UNAVCO***	*GSNL scientists*

ALOS-2	*JAXA*	*POC requests access from JAXA for individual users, data then accessible via UNAVCO****	*GSNL scientists*
Sentinel-1 a/b	*ESA*	*https://scihub.copernicus.eu/*	*Registered public*
PAZ	*INTA*	*POC requests access from INTA for individual users*	*GSNL scientists*
Pleiades	*CNES*	*POC requests access from CNES for individual users*	*GSNL scientists*

NOTE: This list only includes SAR and Pleiades optical data, which typically require payment or approval of a research proposal. Freely available data (e.g., MODIS, Landsat) are not listed.

** Radarsat-1 and ALOS-1 data were available via the legacy Supersite pages, but those links have not worked for over 4 years, and the new Supersite pages do not contain any links to archive data.*

*** Radarsat-2 data have been discontinued as of 2016 owing to an expiration of the SOAR proposal for Hawai'i Supersite data. The Supersite would benefit from a renewal of this proposal, but it is unclear if the project is supported by CSA.*

**** All ALOS-2 data for Hawaii are supplied via RA-4 and RA-6 data grants to the PoC.*

Satellite data issues

Issues regarding data availability and accessibility have not changed over the life of the Hawai'i Supersite. These issues include:

- Links to RADARSAT-1 and ALOS-1 data used to be available on the legacy Supersite web pages, but these never worked, and the legacy pages have now been removed. It is therefore unclear how anyone could gain access to these datasets.

- There is no streamlined method for requesting user access to SAR data; each space agency has a different access policy, some of which require PoC approval (e.g., ASI), others of which do not (e.g., DLR). A single method for "joining" a Supersite and accessing restricted data (mostly SAR imagery) would be preferable, but would obviously be difficult to implement.

- There is no Supersite-specific archive for non-SAR satellite data, like EO-1, Landsat, MODIS, ASTER, and other usually free datasets (although the USGS Hazards Data Distribution System has been stockpiling some imagery of Kīlauea since 2014, and this archive was expanded in 2018 due to the eruption crisis at Kīlauea). This imagery constitutes an important source of information for synergistic studies using SAR and ground-based data. Developing an archive for visual and thermal remote sensing data, as well as other relevant resources (e.g., DEMs, many of which were acquired during Kīlauea's 2018 summit collapse and are available via the USGS Science Base system), would be an important next step in growing the Hawai'i Supersite to a new level of capability and utility. This step will probably require some level of additional funding and personnel, which have been difficult to procure even with the additional attention due to the 2018 eruption crisis.

5. Research results

The past two years have seen numerous research results related to Kīlauea's 2018 flank eruption and summit collapse. Many of these results relied upon Supersite data to support models of the activity and would not otherwise have been possible. The most obvious use of these data was for characterizing the overall event. In this effort, Neal et al. (2019) made extensive use of SAR data to document the precursors, onset, and evolution of the 2018 sequence. One aspect of the activity—the summit collapse—has received special attention because it was the best observed caldera collapse event ever. Using InSAR (Figure 1) and in-situ GNSS data along with observations of lava lake activity, Anderson et al. (2019) were able to characterize the geometry and volume of the magma plumbing system beneath Kīlauea's summit—information that would not otherwise have been known. Among their more noteworthy findings were that caldera collapse initiated after only about 4% of the shallow summit magma system had drained, and the overall event drained less than half (probably only 11-33%) of the shallow summit magma system. This indicates that the eruption did not end due to draining of the shallow summit magma system, but rather by some other means. Segall et al. (2019, 2020) built upon this work by exploring the mechanics of caldera collapse, using a variety of geodetic data to model the subsurface geometry of the collapsing block and its bounding faults.

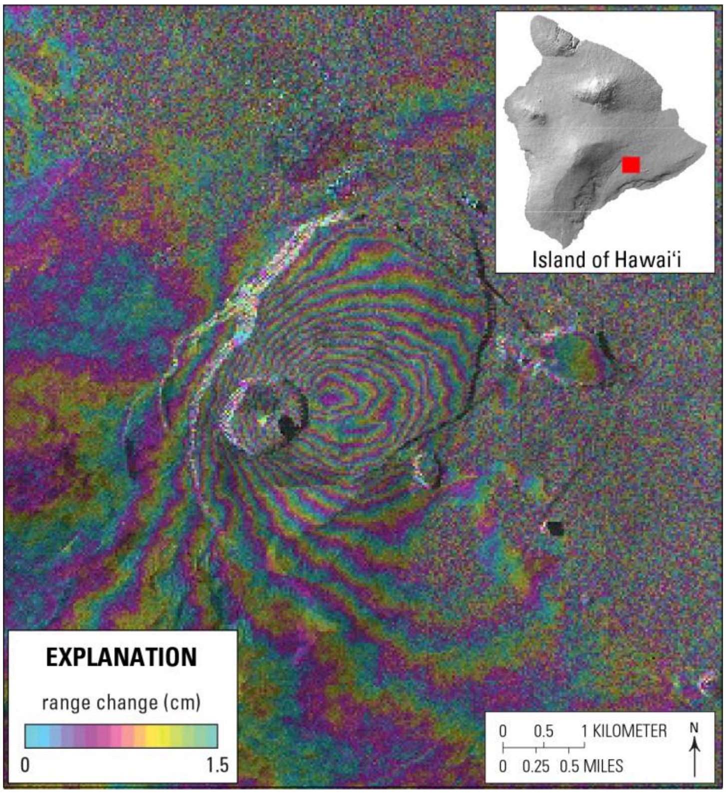

Figure 1. CSK descending-mode interferogram spanning May 9 to May 12, 2018. During this three-day period, over 20 cm of subsidence occurred as the caldera began to collapse due to drainage of magma from a shallow storage area. These data were instrumental to assessing the volume and geometry of that chamber (Anderson et al., 2015).

Supersite data have also been used to support post-2018-collapse research. As an example, Poland et al. (2019) investigated gravity changes from late 2018 (after the collapse) to early 2019 and found that an increase in gravity preceded the onset of caldera inflation, indicating that magma was intruding beneath the caldera in the partially drained storage area but was *probably accumulating in void space and initially unable to pressurize the volume. InSAR data were critical in this research, as they helped to constrain vertical deformation, which needs to be accounted for in any assessment of gravity changes. By about April 2019, however, inflation and uplift was once again manifesting at the summit, and well characterized by InSAR. This inflation has continued unabated since that time and is a clear sign of magma accumulation beneath the summit; in addition, inflation and uplift has been ongoing along the volcano's East Rift Zone since the end of the 2018 activity (Figure 2).*

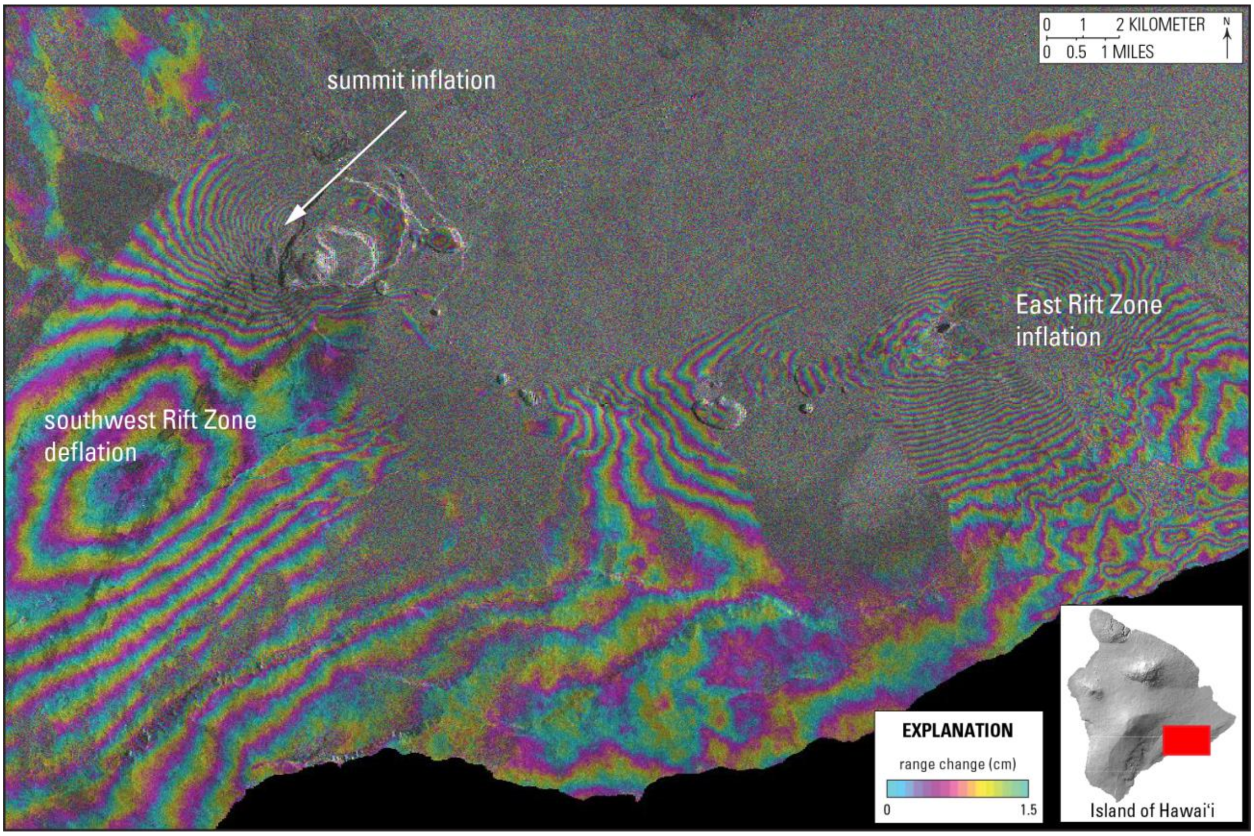

Figure 2. CSK ascending-mode interferogram spanning August 25, 2018 to September 15, 2020. The interferogram documents a number of processes ongoing since the end of the 2018 lower flank eruption and summit collapse, including reinfaltion of the East Rift Zone, reinflation of the summit, and subsidence of the Southwest Rift Zone.

A new SAR dataset has been introduced for Hawai'i as well, from PAZ, a satellite operated by the Instituto Nacional de Técnica Aeroespacial of Spain. These data are available via a PI account to the PoCs, but the results of interferometric and backscatter processing can be shared broadly. PAZ—a clone of TSX—is episodically collecting Spotlight-mode data from Kīlauea's summit. The resulting high-resolution interferograms show an impressive level of detail in terms of summit deformation (Figure 3).

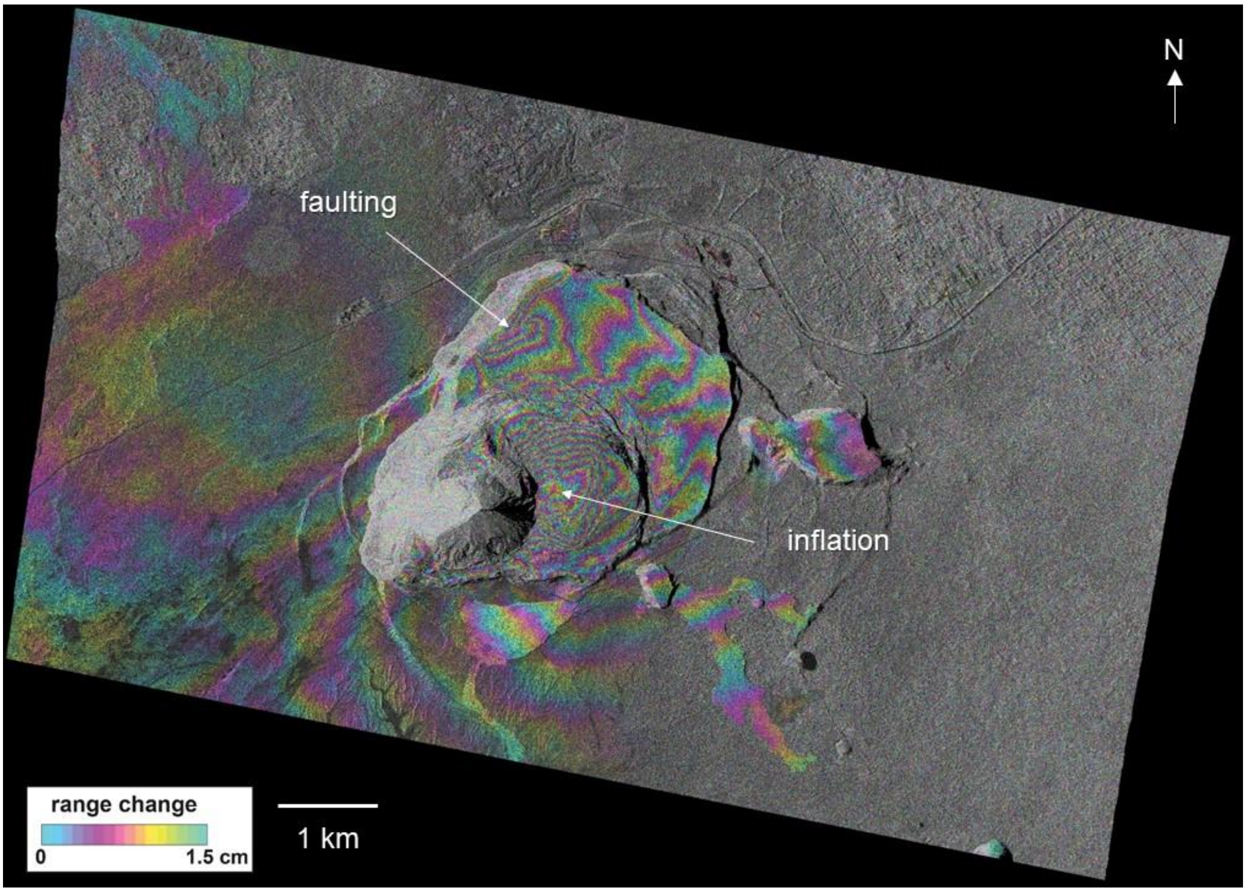

Figure 3. Interferogram of Kīlauea Volcano, Hawaiʻi, made from descending-track PAZ data spanning September 11, 2019 to April 18, 2020. Fringes indicate inflation of the summit area along with movement along small faults in and around the caldera.

Publications

Selected peer-reviewed journal articles

Anderson, K. R., I. A. Johanson, M. R. Patrick, G. Mengyang, P. Segall, M. P. Poland, E. K. Montgomery-Brown, and A. Miklius (2019), Magma reservoir failure and the onset of caldera collapse at Kīlauea Volcano in 2018, Science, 366(6470), eaaz1822, http://doi.org/10.1126/science.aaz1822.

Dzurisin, D., M. P. Poland (2019), Magma supply to Kīlauea Volcano, Hawaiʻi, from inception to now: Historical perspective, current state of knowledge, and future challenges, in Field Volcanology: A Tribute to the Distinguished Career of Don Swanson, edited by M. P. Poland, M. O. Garcia, V. E. Camp and A. Grunder, pp. 275–295, Geological Society of America, https://doi.org/10.1130/2018.2538(12).

Dzurisin, D., Z. Lu, M. P. Poland, and C. W. Wicks (2019), Space-Based Imaging Radar Studies of U.S. Volcanoes, Frontiers in Earth Science, 6, 249, doi:doi:10.3389/feart.2018.00249.

Farquharson, J. I., and F. Amelung (2020), Extreme rainfall triggered the 2018 rift eruption at Kilauea Volcano, Nature, 580(7804), 491-495, https://doi.org/10.1038/s41586-020-2172-5.

Flinders, A., Caudron, C., Johanson, I., Taira, T., Shiro, B., Haney, M. (2020), Seismic velocity variations associated with the 2018 lower East Rift Zone eruption of Kīlauea, Hawaiʻi, Bull. Volcanol., 82(6), 47, https://dx.doi.org/10.1007/s00445-020-01380-w

Ge, S., G. Lin, F. Amelung, P. G. Okubo, D. A. Swanson, and Z. Yunjun (2019), The accommodation of the south flank's motion by the Koaʻe fault system, Kīlauea, Hawaiʻi: insights from the June 2012 earthquake sequence, J. Geophys. Res., 124(11), 11116-11129, doi:https://doi.org/10.1029/2018JB016961.

Kundu, B., R. K. Yadav, R. Bürgmann, K. Wang, D. Panda, and V. K. Gahalaut (2020), Triggering relationships between magmatic and faulting processes in the May 2018 eruptive sequence at Kīlauea volcano, Hawaii, Geophysical Journal International, 222(1), 461-473, https://doi.org/10.1093/gji/ggaa178.

Lundgren, P. R., M. Bagnardi, and H. Dietterich (2019), Topographic Changes During the 2018 Kīlauea Eruption from Single-pass Airborne InSAR, Geophysical Research Letters, 46(16), 9554-9562, doi:https://doi.org/10.1029/2019GL083501.

Patrick, M., I. Johanson, T. Shea, and G. Waite (2020), The historic events at Kīlauea Volcano in 2018: summit collapse, rift zone eruption, and Mw 6.9 earthquake: preface to the special issue, Bull. Volcanol., 82(6), 46, https://doi.org/10.1007/s00445-020-01377-5.

Poland, M. P., E. Zeeuw-van Dalfsen, M. Bagnardi, and I. A. Johanson (2019), Post-collapse gravity increase at the summit of Kīlauea Volcano, Hawaiʻi, Geophysical Research Letters, 46(24), 14430-14439, https://doi.org/10.1029/2019GL084901.

Segall, P., K. R. Anderson, I. Johanson, and A. Miklius (2019), Mechanics of inflationary deformation during caldera collapse: Evidence from the 2018 Kilauea eruption, Geophysical Research Letters, 46(21), 11782-11789, https://doi.org/10.1029/2019GL084689.

Segall, P., K. R. Anderson, F. Pulvirenti, T. Wang, and I. Johanson (2020), Caldera Collapse Geometry Revealed by Near-Field GPS Displacements at Kīlauea Volcano in 2018, Geophysical Research Letters, 47(15), e2020GL088867, https://doi.org/10.1029/2020GL088867.

Wang, K., MacArthur, H., Johanson, I., Brown, E., Poland, M., Cannon, E., d'Alessio, M., Bürgmann, R. (2019), Interseismic quiescence and triggered slip of active normal faults of Kīlauea Volcano's south flank during 2001-2018, Journal of Geophysical Research, 124, 9780–9794, https://dx.doi.org/10.1029/2019jb017419

Conference presentations/proceedings
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…
…

NOTE: It would be impossible to list all presentations that make use of Hawaiʻi Supersite data (there would be several dozen), especially without direct input from science team members; therefore, the table has been left blank. The most important research results are contained within the publication list.

Research products

In a strict sense, the Hawaiʻi Supersite has yet to directly produce any formal community research products. The data have been used by individual investigators to develop products, however, which are having an impact on the overall field. Chief among these are:

- new methods for extracting three-dimensional displacement data from SAR imagery

- deformation maps and time series generated by numerous investigators

- schemes for mapping change due to active volcanism, particularly associated with the emplacement of lava flows (via coherence, amplitude, and topographic data)

- strategies for modeling atmospheric delay

Because these products are either in development for release as part of InSAR processing software (for example, Multiple Aperture Interferometry methods) or are primary research *results or operational tools with specific applications (for example, interferometry time series, topographic change due to lava flow emplacement, and atmospheric modeling strategies), they should not yet be considered research products, and the table below has been left blank.*

Type of product	Product provider	How to access	Type of access
Range change time series	*Falk Amelung, University of Miami*	*http://insarmaps.miami.edu*	*public*
Interferograms	*Various*	*https://winsar.unavco.org/insar/*	*registered*

Research product issues

There are currently few publicly available research products for the Hawai'i Supersite. Time series products from the University of Miami are available to the public, but currently require interacting with a GUI in a manner that may be cumbersome for large-scale analysis. The WInSAR consortium of UNAVCO provides a portal for users to upload and assign DOI numbers to products, like interferograms and time series (https://winsar.unavco.org/insar/). Some interferogram products are available, but users have yet to take widespread advantage of this resource. Several investigators have provided links to time series and deformation maps on their personal websites. Most Supersite researchers, however, have yet to make products available beyond their own publications (although published data are, in most respects, considered open source, and so should be available in manuscript supplements or by contacting the authors). Funding, staff, and other assistance are needed to aid with the dissemination of research products. Few organizations have the funding to develop a resource to its full potential, especially once the research has been published (the "end game" for many scientists). The only exceptions include projects that have been created to specifically develop a resource—for example, the GMTSAR software from the Scripps Oceanographic Institution and the JPL ARIA project—but these are few in number.

6. Dissemination and outreach

The primary means of informing the public of the existence and benefits of the Hawai'i Supersite are outreach efforts, including newspaper articles, social media, and lectures. For example, public presentations on the Island of Hawai'i as part of "Volcano Awareness Month" (every January) and weekly "Volcano Watch" newspaper articles have highlighted the benefit of the Supersite for the assessment and mitigation of volcanic hazards in Hawai'i, and also the greater understanding of Hawaiian volcanoes that the Supersite makes possible (through better access to data and by attracting scientific innovators to work on those data). Outreach to the scientific community is done via conference presentations (highlighting the available datasets and encouraging their exploitation), especially at the American Geophysical Union and the European Geosciences Union annual conferences. The 2018 eruptive activity at Kīlauea has been a focus of a number of special sessions at American Geophysical Union and Geological Society of America meetings. Personal and virtual (the latter especially so since the COVID-19 pandemic) *visits to research institutions and universities around the world allow Supersite researchers to share their results and encourage new users to participate in the work. As a result of these sorts of visits, new attention is being paid to underutilized Supersite resources. For example, a University of Leeds (U.K.) Ph.D. student is examining how amplitude data can be used to better understand activity at Kīlauea, and several scientists have begun to focus on the utility of high-resolution X-band data to investigate localized deformation of the sort that has been observed prior to small magmatic and phreatic explosions at other volcanoes around the world.*

7. Funding

There is no dedicated nor specific funding for the Hawaiʻi Supersite. The Volcano Hazards Program of the U.S. Geological Survey, however, supports the Supersite by directing the PoCs (who are USGS employees) to manage the effort and cultivate a user community. This includes the use of funds from the Volcano Hazards Program's InSAR project to archive and manage SAR data from Hawaiʻi and to build computing resources for SAR data processing and analysis. Individual project scientists have obtained research funding from various organizations—like the U.S. National Science Foundation and NASA—and have leveraged the availability of Supersite data in their proposals.

8. Stakeholders interaction and societal benefits

The most direct beneficiary of the Hawaiʻi Supersite is the U.S. Geological Survey's Hawaiian Volcano Observatory (HVO). Founded in 1912, HVO maintains a dense network of geophysical stations around the island (which have been made available to the Supersite) and also collects geochemical and geological data on volcanic and seismic activity. These measurements fulfill a US Congressional mandate (the Stafford Act) to provide volcano and earthquake hazard warnings, supported by research, to local populations, emergency managers, and land-use planners. SAR data constitute a critical resource for this monitoring and research, but would be cost-prohibitive if not for the Supersite.

HVO communicates hazards information, much of which is aided by Supersite data, to a number of other organizations—primarily the National Park Service and Hawaiʻi County Civil Defense. These agencies are tasked with managing responses to volcanic and earthquake crises in the lands they oversee, while HVO is responsible for providing the information needed by responders to make decisions. This level of cooperative interaction was on display during the 2018 eruptive crisis at Kīlauea, which required close interaction between all three organizations. Supersite and in situ data were used to support multiple public documents about the potential hazards of that, and future, eruptive activity. These documents were released to the public and formed the basis for responses by both Hawaiʻi Volcanoes National Park and the County of Hawaiʻi. Since the end of that episode of volcanism, and during the subsequent pause in Kīlauea eruptive activity, HVO has continued to use Supersite and other data to support research into the 2018 sequence and to provide hazards assessments about future activity at both Kīlauea and Mauna Loa.

Both during and before/after volcanic and seismic crises, Supersite data contribute to the development of interpretations that are communicated to the public as part of daily volcanic activity updates, weekly newspaper articles, online content, and community outreach events (presentations, open houses, exhibits, etc.).

9. Conclusive remarks and suggestions for improvement

The Hawai'i Supersite provided resources that were critical for managing the response to the 2018 Kīlauea lower East Rift Zone eruption and summit collapse, as well as for numerous scientific investigations of the nature of that eruptive activity. Insights form these studies have already contributed to a better understanding of how Hawaiian volcanoes work (for example, the volume of magma storage beneath Kīlauea's summit and the mechanics of caldera collapse) and their current activity (tracking magmatic inflation of both Kīlauea and Mauna Loa).

Since it was established in 2008, the Hawai'i Supersite has provided data and facilitated scientific collaborations that have yielded numerous valuable research and operational results, including:

- understanding of magma supply variations to Kīlauea Volcano and the impact of these variations on eruptive activity,

- elucidation of the magma plumbing systems at Kīlauea and Mauna Loa volcanoes, which provide an essential framework for interpreting past, present, and future unrest,

- investigations into interactions between magmatism and tectonism at Hawaiian volcanoes,

- tracking of geophysical changes—especially deformation and seismicity—at Kīlauea and Mauna Loa, which provides situational awareness of potential future eruptions or changes to ongoing eruptions,

- development of new tools for tracking lava flow emplacement, including both areal coverage and effusion rate, and implementation of these tools in an operational framework to aid volcano monitoring efforts,

- testing of new algorithms for determining 3D displacements from InSAR data,

- providing high-resolution views of small-scale processes, including the formation and evolution of pit craters (at both Kīlauea and Mauna Kea),

- documenting the processes of magma transport, flank motion, and caldera collapse associated with Kīlauea's 2018 activity.

As has been the case since the Supersite was established, a few issues continue to prevent even more comprehensive work by Hawai'i Supersite researchers:

- The scientific teams operate independently, and so there is no organized effort to promote any specific scientific goals. The 2018 activity helped to mitigate this issue by focusing attention on Kīlauea during a number of special sessions at scientific conferences, which resulted in improved coordination between investigators and better exploitation of research opportunities. In addition, it is not clear how the formal science team and participating scientists should be defined for the purposes of this report. Is the science team made up of people and groups that work with Supersite data? Only people/groups that have applied for access to the data? It would be helpful if GSNL could address this ambiguity.

- There is no specific funding for the Hawai'i Supersite, outside of in-kind support by the U.S. Geological Survey. If funding were available, it could be used to better organize the user community and support collaborations and better dissemination of results.

- The revised website for the Hawai'i Supersite does not contain any links to data (including freely available SAR datasets). A more dynamic web presence would allow for posting of research results and products, and it could also be used for dissemination and outreach efforts aimed at not only scientific users and agencies, but also stakeholders and the general public.

A few operational challenges also exist:

- RADARSAT-2 data have not been part of the Hawai'i Supersite for several years. Any RADARSAT-2 data from Hawaii have been acquired via contracts between CSA and the US Government, and the raw data cannot be made available via the Supersite. This is a vastly underutilized resource given the volume of data collected by RADARSAT-2 over Hawai'i.

- Non-SAR satellite data from Hawai'i are not archived anywhere. Such an archive would facilitate data fusion efforts that would merge SAR, visual, and thermal remote sensing imagery to gain new insights into Hawaiian volcanism.

- There is no archive for user-generated supporting data, like DEMs, which could be useful to Hawai'i Supersite investigators, as well as the general public and stakeholders. These items could be stored in the InSAR product archive hosted by WInSAR, but that resource has not yet been used for this purpose.

These challenges should not dissuade support for the continued operation of the Hawai'i Supersite, however, especially given the importance of Supersite datasets in the interpretation and investigation of Kīlauea's 2018 lower East Rift Zone eruption and collapse. The full value of the Hawai'i Supersite has been realized as a result of this activity, with numerous researchers taking advantage of the abundance of data and spectacular activity to pursue numerous innovative studies.

As a final note, the Hawaii Supersite would like to specifically acknowledge the support of ASI, DLR, and CNES. All space agencies have graciously agreed to support Supersite operations, but these organizations are deserving of special thanks for their work in ensuring that these otherwise costly satellite data are not just made available, but also tasked and delivered to Supersite users in a timely manner, which supports both research efforts and operational monitoring.

DATA REQUESTS FOR FUTURE OPERATIONS

SAR data acquisitions have been exceptional during 2019–2020; we have not requested additional Pleiades data because no significant topographic changes have occurred at Kīlauea since 2018. The only data that are not easily accessible, even though there are numerous acquisitions, are from RADARSAT-2. We therefore request that CSA consider reopening their archives of already collected RADARSAT-2 data for access by Supersite researchers. These data, due to their unique resolution, polarization, and long history of acquisitions, constitute critical value added that are not be available from any other source.

10. Dissemination material for CEOS (discretionary)

Please see section 5.