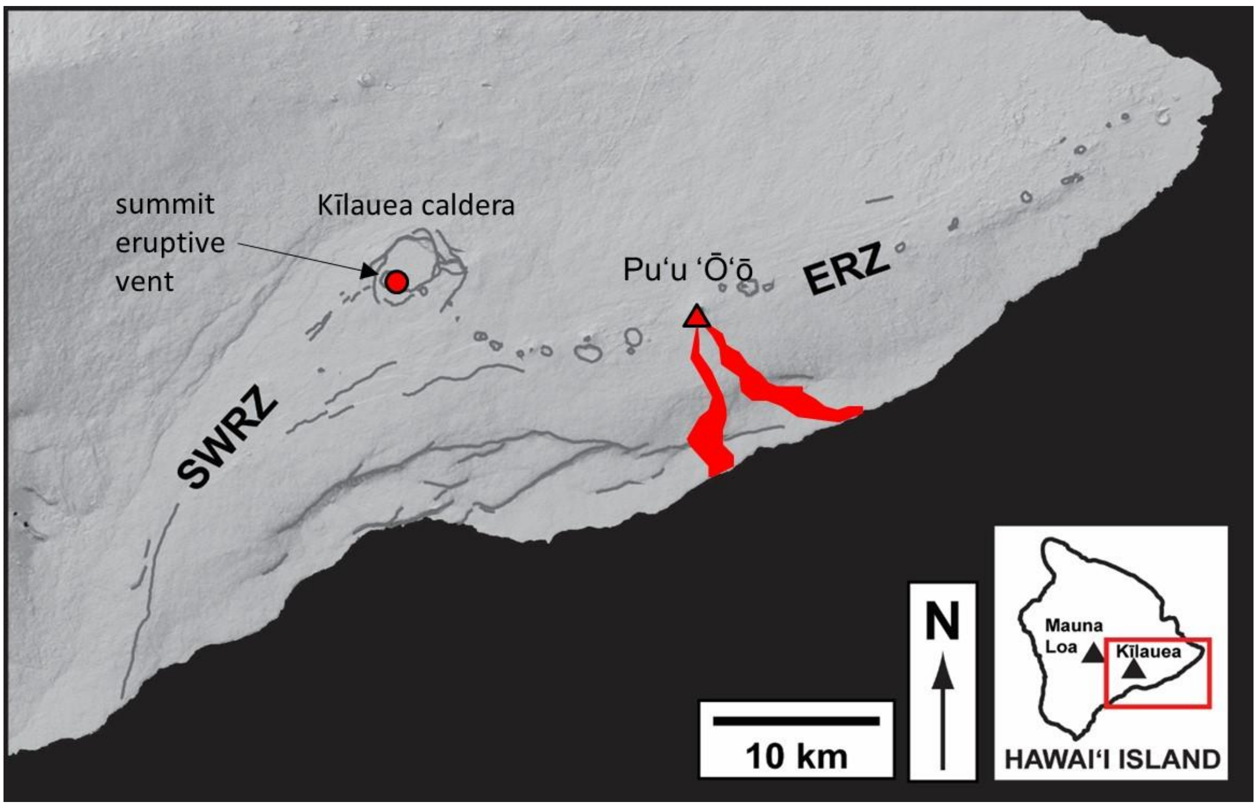
Hawai‘i Supersite success story

Supporting the response to the 2018 lower East Rift Zone and summit collapse at Kīlauea Volcano, Hawai‘i

Since 1983, Kīlauea Volcano, on the Island of Hawai‘i, has actively erupted from vents on the volcano's East Rift Zone in the vicinity of the Pu‘u ‘Ō‘ō cone. Lava from this long-term eruption was responsible for destroying over 200 homes, including nearly all of the village of Kalapana on the southeast coast of the island. This East Rift Zone eruption was joined in 2008 by eruptive activity at the summit, where a persistent lava lake formed in a vent nested inside Halema‘uma‘u crater within Kīlauea caldera. Summit activity was responsible for greatly increased gas emissions that especially impacted the south and west parts of the island.

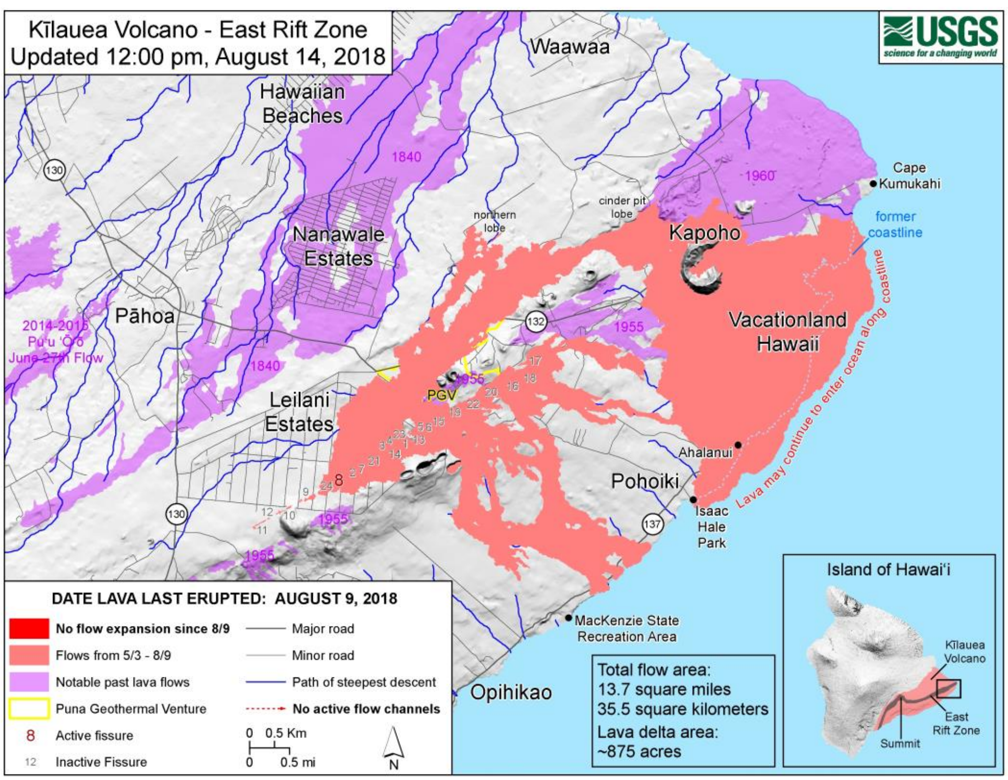


Kīlauea Volcano, on the Island of Hawai‘i. Rift zones radiate to the east (ERZ=East Rift Zone) and southwest (SWRZ=Southwest Rift Zone) from the summit caldera. Vents in the vicinity of Pu‘u ‘Ō‘ō have been actively erupting lava (noted by red areas) since 1983, and a lava lake has been present at the summit since 2008.

The Hawai‘i Supersite was initiated in 2008 (and made permanent in 2012) as a means of supporting scientific investigations into volcanic and earthquake activity on the Island of Hawai‘i, and also to provide data in support of emergency management operations in the event of a volcanic crisis.

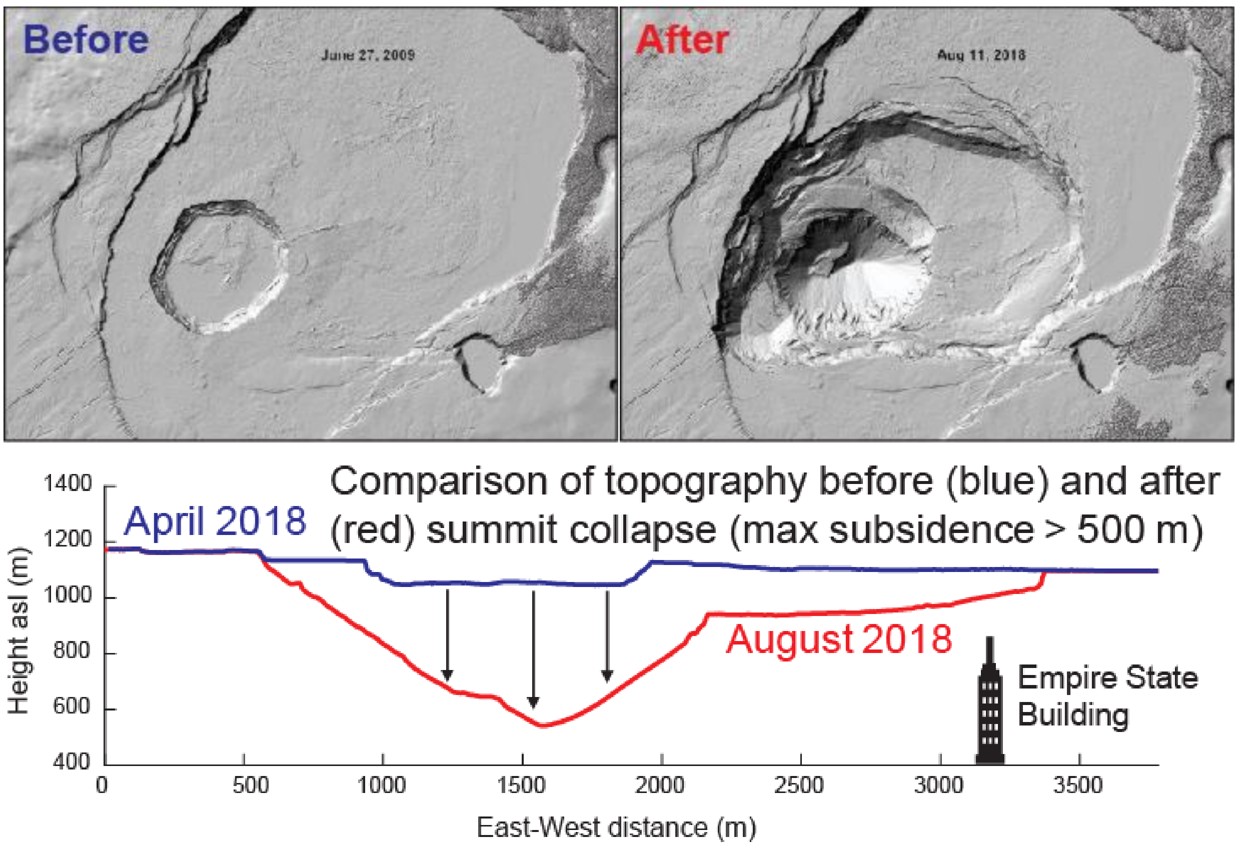
In early 2018, inflation of the Puʻu ʻŌʻō eruptive vent suggested an impending change in eruptive activity. Past inflation events at Puʻu ʻŌʻō have culminated in the formation of a new eruptive vent, usually within a few kilometers of Puʻu ʻŌʻō. By April 17, the Hawaiian Volcano Observatory issued a Volcanic Activity Notice that warned of a potential change in the behavior of the volcano.

On April 30, the crater floor of Puʻu ʻŌʻō collapsed as magma drained to feed a new magmatic intrusion. Unlike past intrusions since 1983, this one propagated quite far down the East Rift Zone, emerging 20 km from Puʻu ʻŌʻō (40 km from the summit) in the Leilani Estates subdivision. The opening of the rift zone—estimated to be at least 4 meters in some places—caused stress to build on the fault that underlies Kīlauea's south flank, and on May 4 the fault ruptured in a M6.9 earthquake. During that event, which was the largest earthquake in Hawaiʻi since 1975, the south flank moved towards the sea by about 0.5 meters. Over the ensuing weeks, 24 individual eruptive fissures formed along Kīlauea's lower East Rift Zone. By late May, eruptive activity focused on a single fissure, which fed a lava flow that reached the ocean at the eastern tip of the island. The eruption rate remained very high—some of the highest sustained lava eruption rates ever recorded in Hawaiʻi—until early August, when activity waned and mostly ended. By this time, the lava flow field covered 35.5 km^2, 875 acres of new land had formed along the coastline, over 700 homes had been lost, and over 45 km of roads were inundated due to the eruption of about 0.8 km^3 of lava—equivalent to about 8 years of magma supply to the volcano.



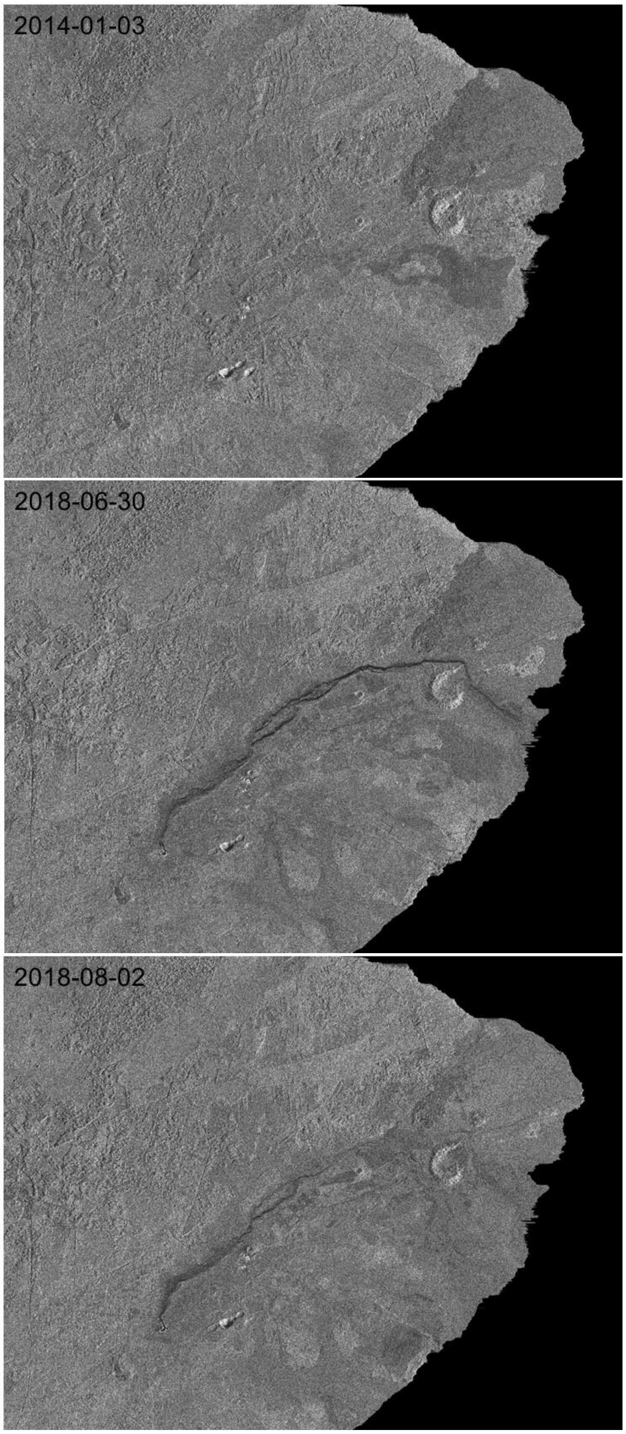
Map of Kilauea's lower East Rift Zone generated by the Hawaiian Volcano Observatory on August 14, 2018. Purple areas indicate regions of past lava flows (in 1840, 1955, and 1960), while red areas are from 2018. Blue lines indicate topographic paths of steepest descent, which were used to forecast initial flow paths. Black lines are roads.

The massive effusion of lava caused an extraordinary amount of summit deflation as magma chambers beneath Kīlauea caldera drained to feed the lower East Rift Zone eruption. The subsidence occurred in piecemeal fashion starting in earnest by late May, and near-daily ~M5.2 earthquakes accompanied many meters of caldera floor subsidence. During May and June, ash plumes were generated during the collapse events, some reaching as high as 30,000 feet above sea level. By early August, when subsidence ceased, the caldera floor had dropped by a maximum of 500 meters, with a total volume loss (based on comparisons of topographic maps from before and after the collapse) of about 0.825 km^3—the largest collapse in the 200 year written history of the volcano.

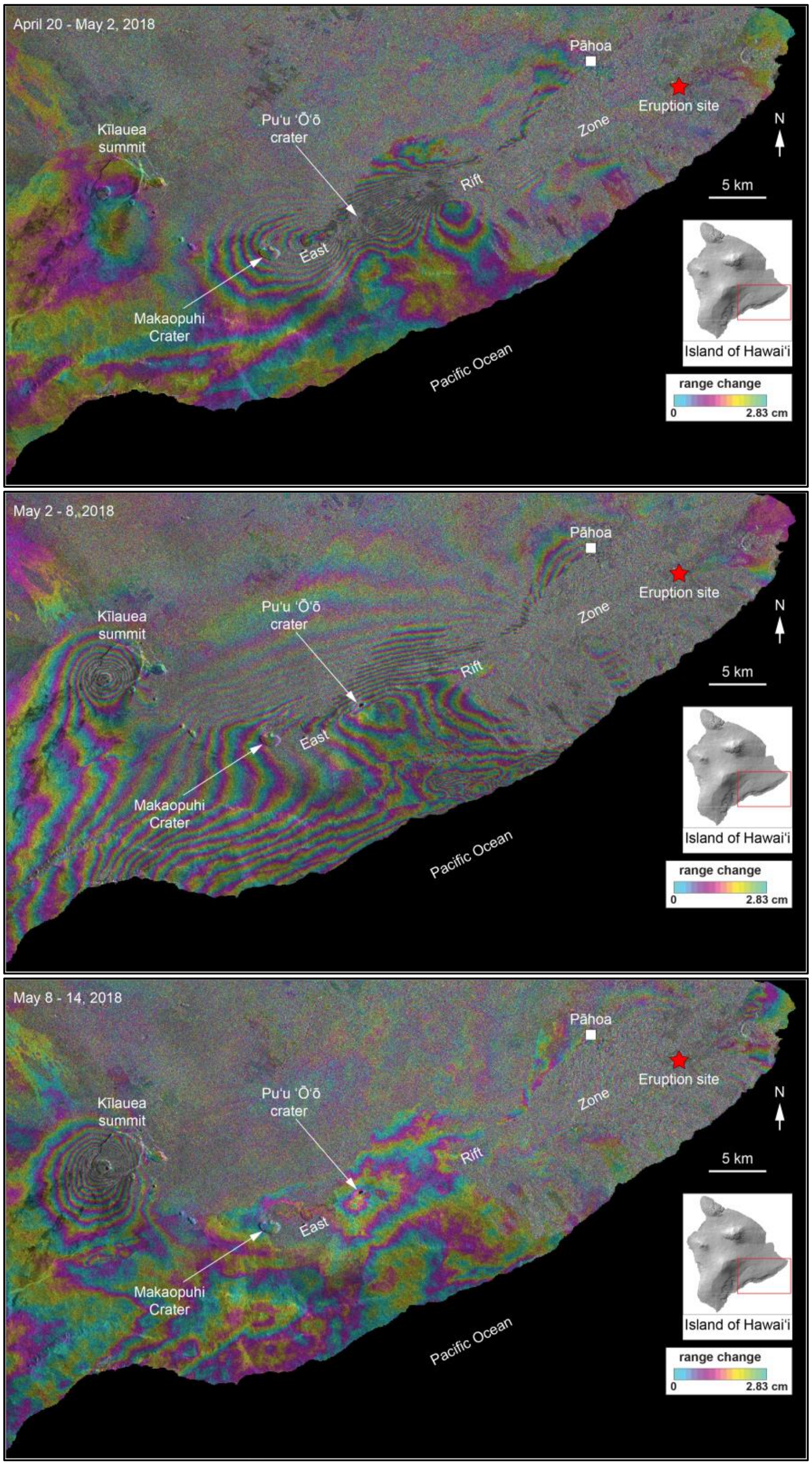


Top panels show shaded relief maps from before and after Kīlauea's summit collapse. Bottom profile gives east-west cross section through the area of maximum subsidence, which exceeded 500 meters.

A variety of datasets were used to track Kīlauea's eruptive activity. Ground-based sensors included GNSS and tilt stations to record surface deformation and seismometers to measure earthquake activity. Space-based resources were especially valuable for the synoptic view provided by satellite imagery. In particular, Synthetic Aperture Radar (SAR) data were critical for assessing surface deformation over broad areas and tracking changes in surface characteristics due to collapse at the summit and lava flow activity in the lower East Rift Zone. These data formed a crucial component of the eruption response by the U.S. Geological Survey Hawaiian Volcano Observatory (HVO), which reported observations of eruptive activity and forecasts of the likely evolution of the volcanism to Hawai'i County Civil Defense, which was the agency tasked with the management of the crisis. HVO will also lead the scientific response to the eruption. Globally, no caldera collapse event has been as well recorded. Future studies will address not only the dynamics of the lava flow effusion and summit collapse, but also how Kīlauea recovers from this massive disruption to its magmatic system. In this work, the Hawaiʻi Supersite will be an invaluable resource for scientists around the world who are contributing to a better understanding the evolution and hazards of Kīlauea, and other volcanoes by analogy.



TerraSAR-X amplitude images of the lower East Rift Zone of Kīlauea Volcano from before (top), during (middle), and near the end (bottom) of the 2018 eruptive activity. The data capture the development and subsequent degradation of a lava channel (indicated by dark sinuous lines).



Sequence of Sentinel-1 interferograms spanning the initiation of the lower East Rift Zone dike intrusion (top), onset of lower East Rift Zone eruption and M6.9 south flank earthquake (middle), and co-eruption, post-earthquake time periods (bottom).

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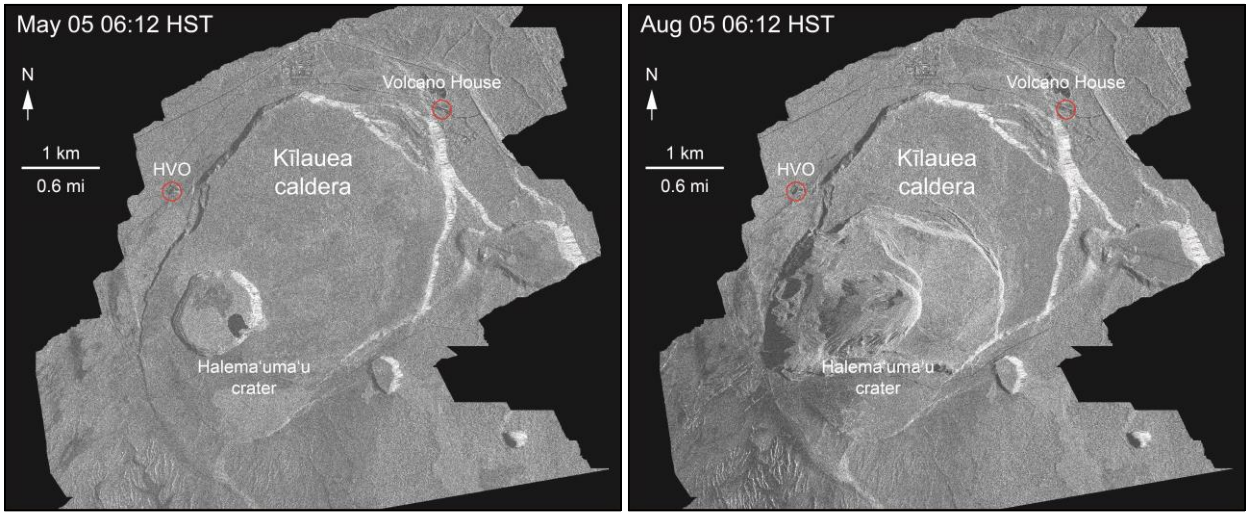

Cosmo-SkyMed amplitude data from before (left) and after (right) collapse of Kīlauea's summit caldera. Images are registered to a LIDAR DEM, which has no data in areas that are black. Red circles indicate the locations of the Hawaiian Volcano Observatory (HVO) and Volcano House hotel on the rim of Kīlauea caldera.

For more information on the 2018 lower East Rift Zone and summit collapse of Kīlauea Volcano, visit https://volcanoes.usgs.gov/observatories/hvo/activity_2018.html.