

### ***A.1 Proposal Title***

Hawaiian Volcanoes Supersite

### ***A.2 Supersite Point-of-Contact (PoC)***

Michael Poland  
Geophysicist  
U.S. Geological Survey  
Hawaiian Volcano Observatory  
51 Crater Rim Drive  
Hawaii National Park, HI 96718  
USA  
Tel: +1 808-967-8891  
Fax: +1 808-967-8890  
Email: [mpoland@usgs.gov](mailto:mpoland@usgs.gov)

To sign legal license agreements, contact:

James Kauahikaua  
Scientist-in-Charge  
U.S. Geological Survey  
Hawaiian Volcano Observatory  
51 Crater Rim Drive  
Hawaii National Park, HI 96718  
USA  
Tel: +1 808-967-8824  
Fax: +1 808-967-8890  
Email: [jimk@usgs.gov](mailto:jimk@usgs.gov)

### ***A.3 Core Supersite Team and organization***

Michael Poland (Geophysicist, USGS Hawaiian Volcano Observatory): Has over 15 years of experience with volcanology and volcano deformation, is located on-site in Hawaii, and can provide ground-based assessment of volcanic activity (especially as related to remote sensing datasets). Poland will coordinate satellite tasking and distribute data as required by agreements with individual space agencies, and he will also consult with the HVO Scientist-in-Charge on making available ground-based datasets collected by the USGS Hawaiian Volcano Observatory.

Falk Amelung (Professor, University of Miami): Has over 15 years of experience in applying InSAR to active volcanoes and modeling deformation sources. Much of Amelung's recent research has focused on deformation of basaltic ocean island volcanoes, including those on the Island of Hawaii.

Paul Lundgren (Research Scientist, NASA Jet Propulsion Laboratory): Has over 10 years of experience in analyzing and modeling volcano deformation derived from InSAR. Lundgren is one a lead research scientist on NASA's UAVSAR mission and coordinates data collection over volcanic targets (including Hawaii).

The core supersite team has excellent capacity to exploit not only the variety of space-based datasets, but also airborne and ground-based volcano monitoring data. All three scientists above

have experience in merging multiple datasets to analyze subsurface processes and have a history of collaboration in Hawaii, especially with regard to SAR data.

#### ***A.4 Other Supersite Research Teams***

Stanford University: For over 20 years, researchers at Stanford University (California, USA) have actively researched deformation of Hawaiian volcanoes, including collaborations with the Hawaiian Volcano Observatory on both space- and ground-based observations. Principle investigators at Stanford are Paul Segall and Howard Zebker.

IREA-CNR: Riccardo Lanari, Eugenio Sansosti, and many other researchers at IREA-CNR, Italy, have developed cutting-edge InSAR analysis techniques and will contribute their expertise to SAR datasets of Hawaiian volcanoes—particularly Kilauea, which is one of the most intensely deforming volcanoes in the world.

GFZ German Research Centre for Geosciences: Thomas Walter at the GFZ research center at the University of Potsdam, Germany, has been studying deformation of Hawaiian volcanoes for over 10 years. Walter focuses on a variety of remote measurements (from satellite SAR data to Webcam imagery) to constrain models of volcano-tectonic processes.

INGV: The Istituto Nazionale di Geofisica e Vulcanologia is charged with monitoring seismic and volcanic activity in Italy. Collaborations are developing between INGV and USGS scientists to take advantage of shared knowledge given similarities between Italian and US volcanoes. For example, both Etna (Italy) and Kilauea (USA) are frequently active, experience flank deformation, and show variable styles of deformation over short (days to years) time periods. INGV scientists with interest in the Hawaii Supersite include Simone Atzori and Giuseppe Puglisi, among many others.

University of Wisconsin: The University of Wisconsin (Madison, Wisconsin, USA) is home to researchers that combine innovative geophysical techniques, including specific advancements in InSAR analysis. Kurt Feigl and Cliff Thurber study volcano deformation and seismicity, and both are conducting research on active volcanism in Hawaii in collaboration with researchers at the Hawaiian Volcano Observatory.

#### ***A.5 Supersite description and justification***

The Geohazards Supersite concept, organized by the Group of Earth Observation (GEO), is intended to facilitate access to space and in-situ data for regional areas exposed to geological threats. The principal objective is to encourage basic research of earthquake, volcano and other hazardous geological processes as a means of reducing the loss of life from geological disasters.

Hawaii is home to two of the most active volcanoes in the world—Kilauea and Mauna Loa—and is one of the most seismically active places in the United States. Kilauea Volcano has been eruption continuously from a vent on its east rift zone since 1983, and from a vent within its summit caldera since 2008. Mauna Loa, which was most recently active in 1984, is the largest volcano by volume in the world and its eruptions often threaten populated areas. Hawaii was chosen as a volcanic hazards Supersite due to the presence of a population exposed to volcanic hazards, the high likelihood of future eruptive activity and changes in existing activity, and the history of Kilauea and Mauna Loa as volcanoes that stimulate basic volcanological research.

The USGS Hawaiian Volcano Observatory (HVO), founded in 1912, maintains a dense network of geophysical stations around the island (and especially on Kilauea and Mauna Loa) 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. In-situ datasets include gas emissions, geologic maps, thermal and visible camera imagery, petrologic time series, earthquake locations, gravity change, and deformation (primarily from GPS and tilt). Most of these data are available to the scientific community in either raw or reduced formats. For example, gas emission data are analyzed and published on a regular basis as USGS Open-File reports (currently up-to-date to 2010). GPS data are accessible via the UNAVCO archive. Continuous seismic data for most stations on the Island of Hawaii since 2011 can be obtained through IRIS, and hypocenters for all recorded earthquakes > M1.7 are available from the Northern California Earthquake Data Center and the National Earthquake Information Center. Recent helicorder and hypocenter data are also posted on HVO's Web site, along with geologic data (maps and thermal/visible imagery). Long-range plans include the archiving of additional continuous waveform data at IRIS but are limited by funding and staffing constraints. Other data, for example, tilt and gravity, are archived only at HVO because there are no standard archive or metadata formats nor data centers to ingest such records. The USGS Volcano Science Center is working towards establishing a Volcano Data Center, which would archive and distribute volcano monitoring data as part of a National Volcano Early Warning System (NVEWS), but funding for NVEWS has not yet been approved by the US Congress. Scientists who are interested in working with HVO scientists on data that are not yet publically available should contact the HVO Scientist-in-Charge to discuss collaborative research efforts.

The comprehensive suite of monitoring observations and instrumentation strengthen Hawaii's utility as a Supersite because it allows for the best possible synergy between diverse space-based, ground-based, and airborne data. In addition, Hawaiian volcanoes are easily accessible by car, foot, or short helicopter flights, and are therefore conducive to repeated experiments and technological development. While physically easy to access, however, legal accessibility rests with land owners and land managers, including the US National Park Service, Hawaii Department of Land and Natural Resources, Hawai'i County Civil Defense, and private citizens. Researchers who are interested in physical access to Hawaiian volcanoes should contact HVO to discuss their projects and requirements.

Few places on Earth have the a combination of seismic and volcanic activity, history of continuous observation, and accessibility as Hawaii. By merging in-situ datasets with those available from satellite platforms, it is possible to address large-scale research questions in Hawaii. For example, what is the nature of magma supply to Hawaiian volcanoes? What data provide the best indication that a volcano may erupt? How can predictions of the timing, magnitude, and location of volcanic eruptions be improved? What is the relation between volcanic and tectonic activity? Preliminary investigations into these topics using combined space- and ground-based data have been successful in detecting changes in magma supply to individual volcanoes, providing advance warning of eruptive activity, and mapping feedback between volcanic and tectonic processes.

As one of the best-monitored volcanic settings in the world, Hawaii is also an excellent analog to other locations. For example, Hawaii compliments the Etna (Italy) Supersite because both locations

experience flankinstability and frequent changes in eruptive activity. Lessons learned in one location may therefore be applicable to the other. Hawaii is also considered the type example for basaltic volcanism on the Earth and other planets. Insights that are facilitated by Hawaii's status as a Supersite can therefore be transferred to locations like the Galapagos (Ecuador), Azores (Portugal), Reunion (France), and even such distant volcanoes as Olympus Mons (on the planet Mars).

Local support for the Hawaii Supersite is provided by HVO, which ensures consistency of observations over time. HVO researchers are active Supersite participants, and the Supersite concept has been endorsed by the USGS Natural Hazards Mission Area (which includes the Volcano Hazards Program).

#### *A.6 Current or future use of requested data*

The most critical data needed for the Hawaii Supersite are satellite-based SAR imagery. Current contributors to the Supersite include ASI (Cosmo-SkyMed SAR imagery) and DLR (TerraSAR-X SAR imagery). Archival data has also been contributed by ESA (ENVISAT), JAXA (ALOS), and CSA (RADARSAT-1). These data, and data from other current and future SAR missions (for example, CSA's RADARSAT-2 and ESA's Sentinel program) are critical to mapping detailed patterns of surface deformation over space and time and support hazards assessment by HVO (especially when the data are available within hours of acquisition), while also serving as fundamental inputs to models of volcanic and tectonic activity in Hawaii. Complimentary remote sensing data, including visible (e.g., EO-1) and multispectral (e.g., MODIS) imagery, are already available to many volcano researchers. SAR scenes therefore represent a crucial dataset to Hawaii researchers that might not be possible without Supersite support. Indeed, given the failure of ALOS in 2011 and ENVISAT in 2012, the Hawaii research community would not have general access to SAR data without the support of the Hawaii Supersite, which negotiated agreements with ASI and DLR for the availability of Cosmo-SkyMed and TerraSAR-X images.

#### *A.7 Schedule*

The Hawaii Volcanoes Supersite has already been established and hosts a variety of space- and ground-based data, including SAR imagery from the RADARSAT-1, ENVISAT, TerraSAR-X, ALOS, and Cosmo-SkyMed satellites and the UAVSAR airborne system, and ground-based measurements of seismicity, gas emissions, geologic changes, and deformation. The Web site for the Hawaii Volcanoes Supersite is <http://supersites.earthobservations.org/hawaii.php>. As more ground-based data become available, they will be added to the Supersite. We are also hopeful that other space-based data (for example, visible and thermal imagery) may eventually be part of the Supersite.

#### *A.8 Detailed geographic region of interest*

The Hawaii Volcanoes Supersite covers the Island of Hawaii in the United States and includes the actively erupting Kilauea Volcano, recently active (within decades to centuries) Mauna Loa and Hualalai volcanoes, and less active (most recent eruption thousands to tens of thousands of years ago) Mauna Kea and Kohala volcanoes. The island is bounded by 18.9°-20.3°N latitude and 154.8°-156.1°W longitude; the center of Kilauea's summit caldera is at 19.41°N, 155.27°W.

#### *A.9 Data requirements*

Because Hawaii is located at tropical latitudes where snow accumulation is negligible (except sporadically at the summit of Mauna Loa and Mauna Kea volcanoes), year-round SAR imagery is requested as part of the Hawaii Volcanoes Supersite. Specifically, frequent acquisitions over Kilauea

and Mauna Loa are needed to characterize rapidly evolving deformation patterns and surface change. For example, deformation associated with dike intrusions and fissure eruptions takes place over hours to days. Although InSAR provides the excellent spatial resolution needed for detailed models of dike opening, the evolution of dike emplacement over time (and especially the first few hours of dike propagation) is poorly known because SAR acquisitions are not generally frequent enough to provide sufficient temporal resolution of deformation. In addition, InSAR coherence and SAR amplitude can be used to map lava flow emplacement and other surface change. The greater the number of acquisitions, the finer the temporal resolution of change mapping and the better the derived models of, for example, lava flow behavior and hazards assessment.

Ideally, SAR imagery should be acquired of Kilauea and Mauna Loa every ~2 weeks (every 11 days for TerraSAR-X and 16 days for Cosmo-SkyMed) from both ascending and descending tracks (to provide complimentary perspectives of deformation). Current tasking plans provide 100 scenes per year from ascending and descending tracks of Cosmo-SkyMed (50 each at Kilauea and Mauna Loa) and ~66 scenes per year from ascending and descending tracks of TerraSAR-X (mostly covering Kilauea). During periods of heightened activity (for example, rapid inflation of Kilauea's summit that might precede a change in the ongoing eruptions), more frequent SAR acquisitions will be requested (for example, 1-, 4-, and 8-day repeats by Cosmo-SkyMed). The same polarization should be used for all acquisitions from a single satellite to ensure maximum compatibility with archived imagery. If available, multiple polarizations (for example, as was the case with ALOS FBD mode) would facilitate explorations of the utility of different polarizations for geologic mapping—an application which is not well understood.

Experience demonstrates that all SAR bands provide excellent data from Hawaiian volcanoes because recent lava flows are coherent at all wavelengths over several years. L-band offers the best coherence in vegetated areas (for example, on the north side of Kilauea's east rift zone), while X-band offers the finest resolution of small-magnitude deformation. A mix of SAR bands is therefore the best approach to tracking deformation of Hawaiian volcanoes using InSAR.

#### ***A.10 Available resources***

Research involving the Hawaii Supersite will be done using resources provided by major scientific research institutions, including the U.S. Geological Survey and NASA, and by university scientists supported by grants from agencies like the US National Science Foundation. The USGS Hawaiian Volcano Observatory contributes much of the ground-based data to the Supersite and is the home institution for the Supersite POC. They will support research by USGS scientists into volcanic processes in Hawaii using Supersite data. NASA similarly supports several scientists who conduct research in Hawaii. A variety of academic scientists from various universities, for example, Stanford University, the University of Miami, and the University of Wisconsin, are supported by external grants to investigate volcanic and tectonic processes in Hawaii.

#### ***A.11 Additional comments***

N/A