# A Google Earth Engine application for mapping volcanic thermal anomalies at a global scale by means of Sentinel 2 MSI and Landsat 8 OLI data

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# NHI Algorithm

The NHI (Normalized Hotspot Indices) algorithm combines two normalized indices to identify and map volcanic thermal anomalies on OLI/MSI data:

$$NHI_{SWIR} = \frac{L_{2.2} - L_{1.6}}{L_{2.2} + L_{1.6}}$$

$$NHI_{SWNIR} = \frac{L_{1.6} - L_{0.8}}{L_{1.6} + L_{0.8}}$$

where, $L_{2.2}$, $L_{1.6}$, and $L_{0.8}$ are the TOA radiances [$W \cdot m^{-2} \cdot sr^{-1} \cdot m^{-1}$] measured, for each pixel of the analyzed scene, at around 2.2 µm, 1.6 µm(SWIR), and 0.8 µm (NIR) wavelengths.

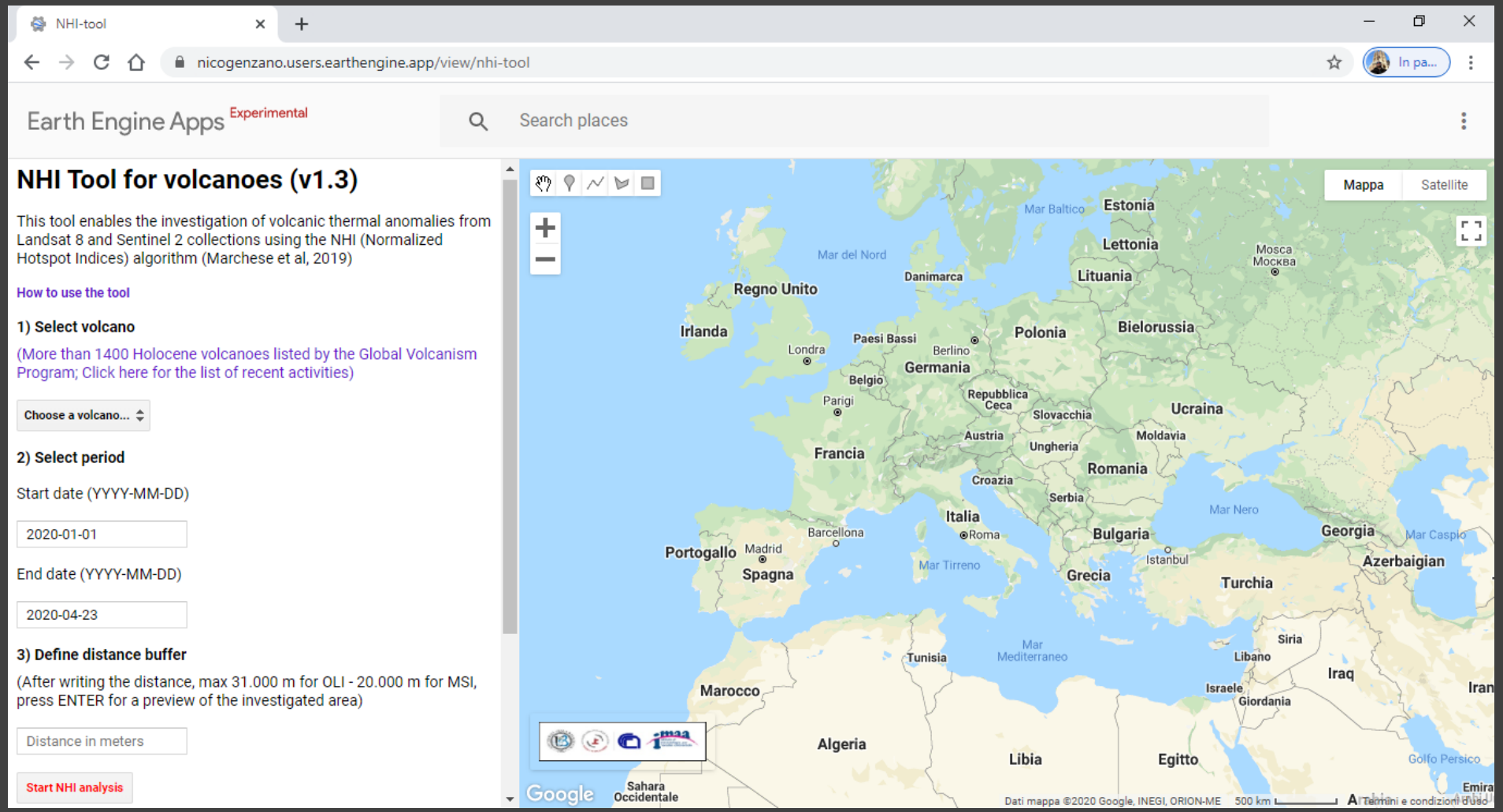
Values of $NHI_{SWIR} > 0$ *OR* $NHI_{SWIR} > 0$ are used to detect volcanic hotspots.

Reference: Marchese, F.; Genzano, N.; Neri, M.; Falconieri, A.; Mazzeo, G.; Pergola, N. A Multi-Channel Algorithm for Mapping Volcanic Thermal Anomalies by Means of Sentinel-2 MSI and Landsat-8 OLI Data. Remote Sensing 2019, 11(23), 2876, https://doi.org/10.3390/rs11232876

# NHI tool

The NHI-tool is the first Google Earth Engine (GEE) tool developed to map volcanic thermal anomalies

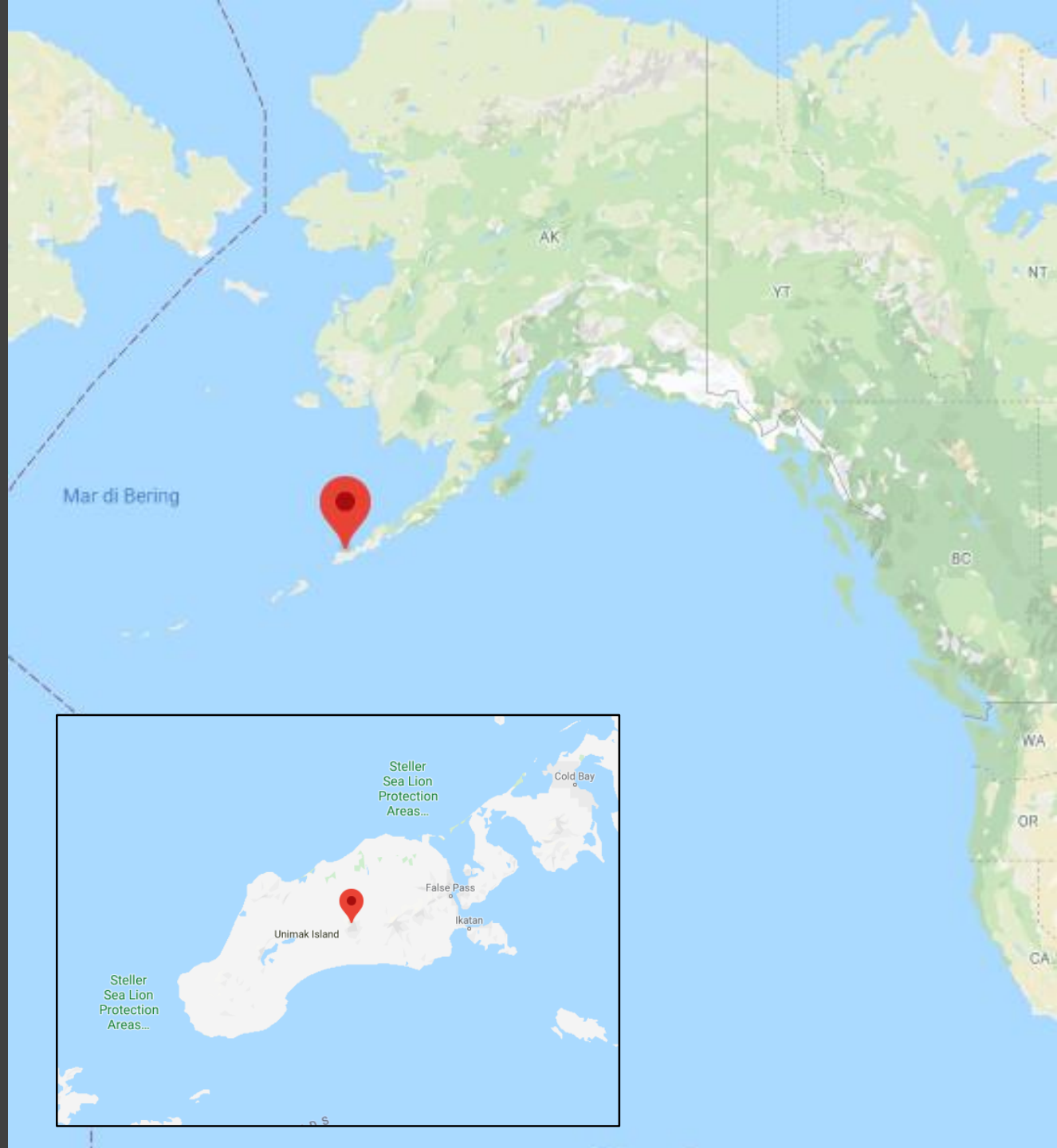
This free-available GEE-App currently enables the investigation of about 1400 active volcanoes by means of Landsat 8 and Sentinel 2 data



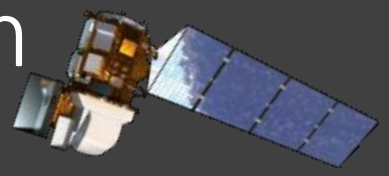

https://nicogenzano.users.earthengine.app/view/nhi-tool

# Example 1
# *Shishaldin (lava flows)*

Shishaldin
United States
54.756°N, 163.97°W

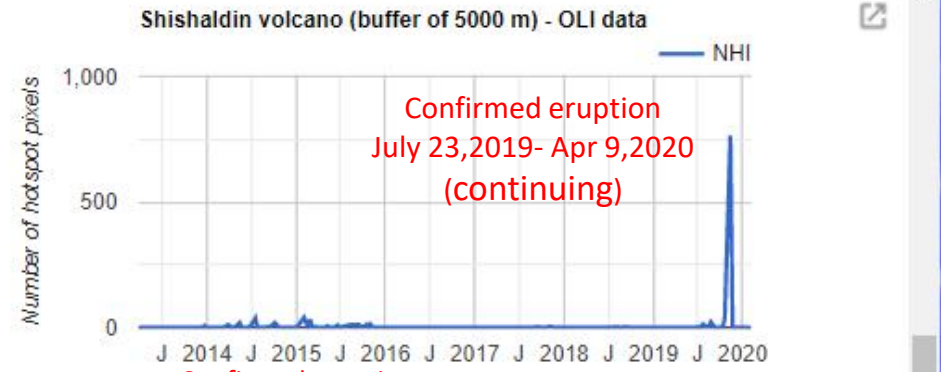


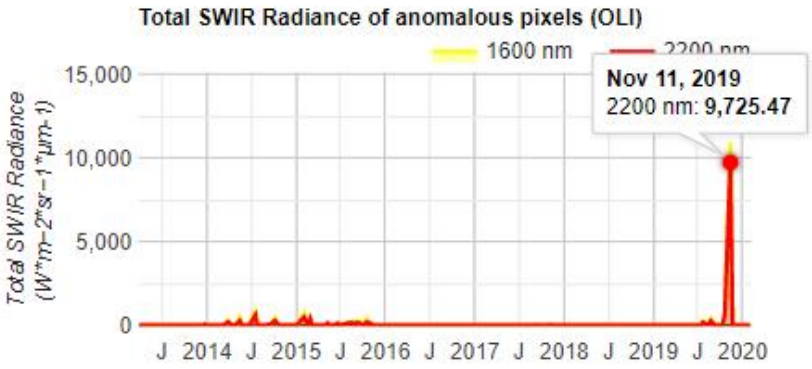
# **Shishaldin** volcano long-term observation performed using Landsat 8/OLI data



Google Earth Engine

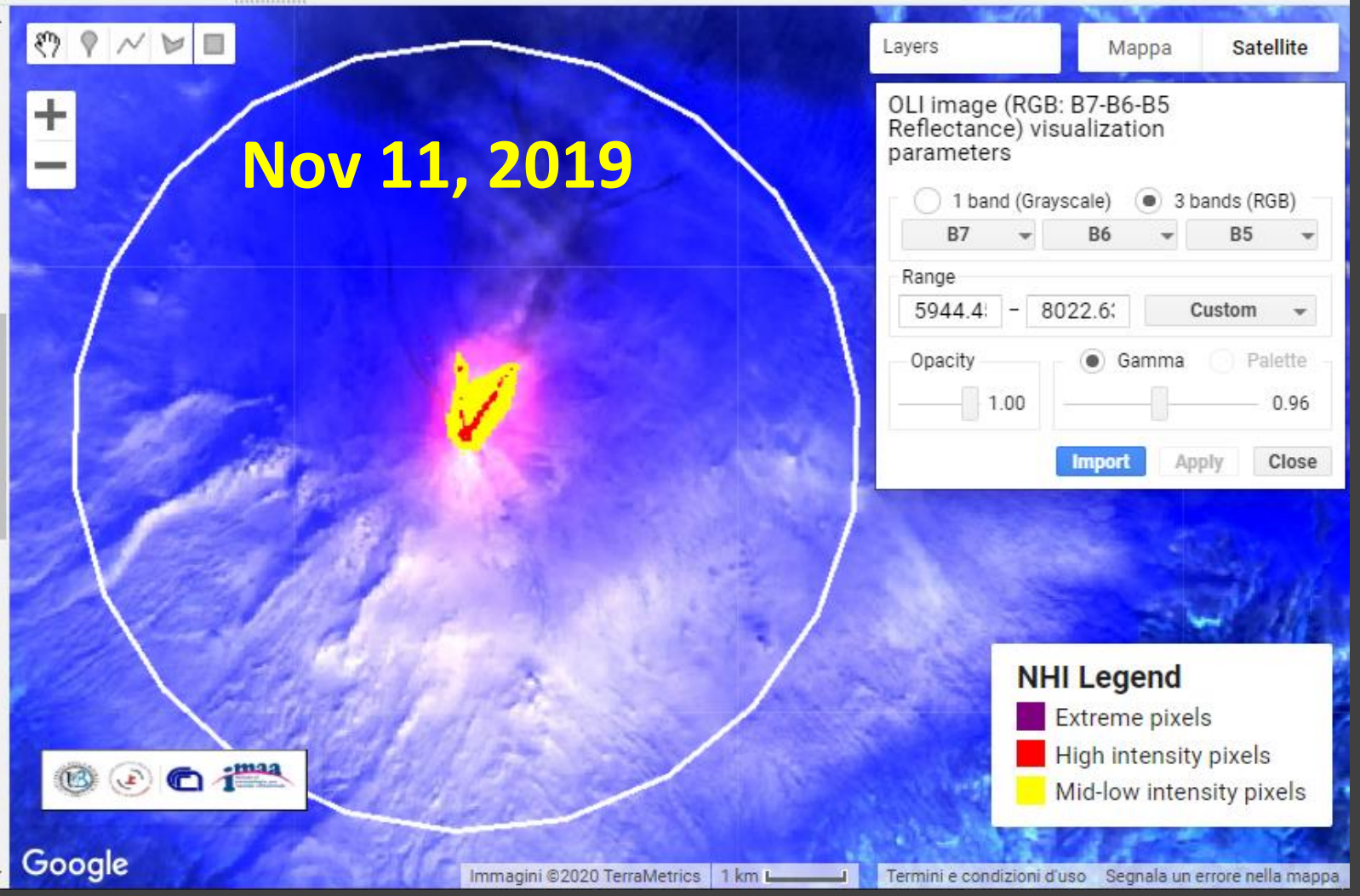
Search places and datasets...



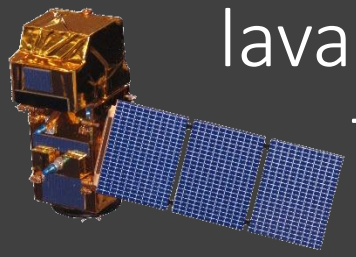

**4) Select a Landsat 8 image to visualize**

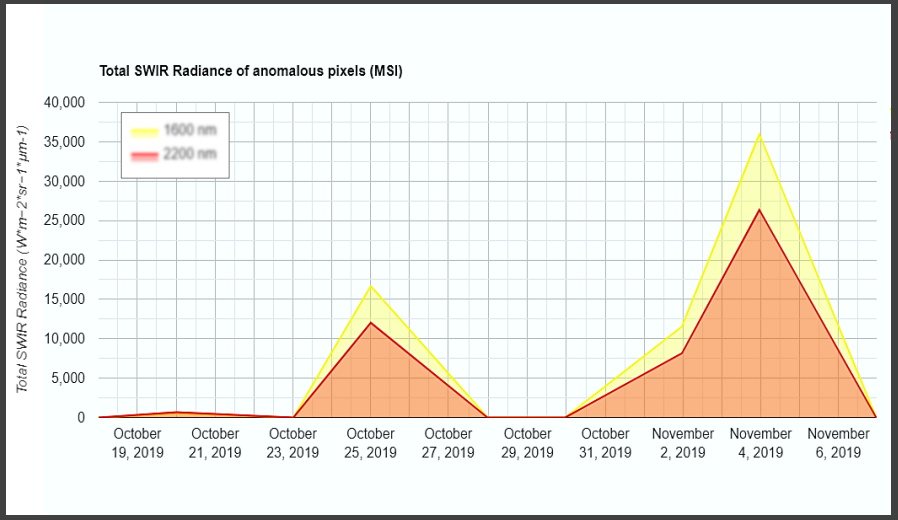
LC08_076022_20191111



# Shishaldin

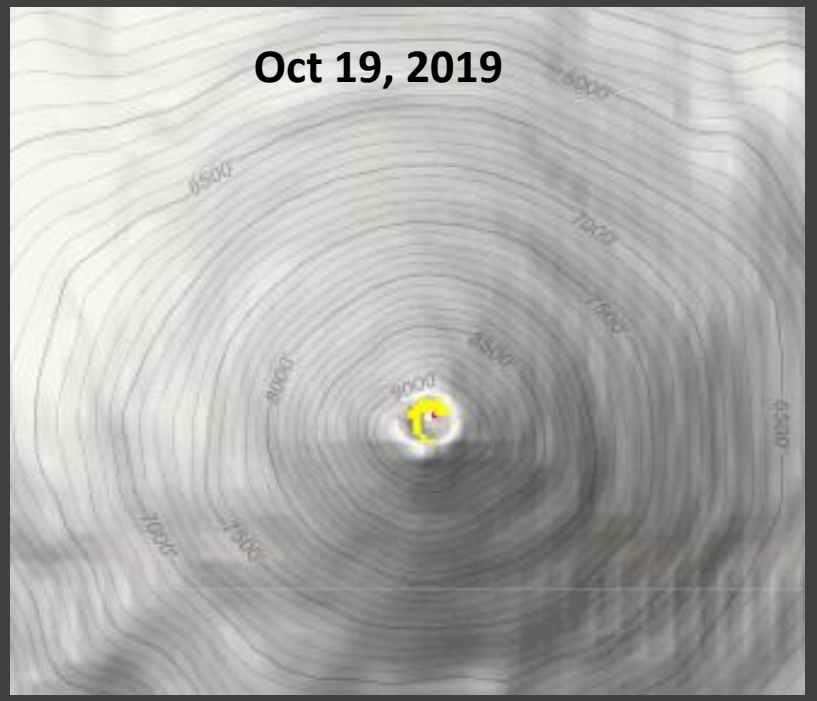
## lava flow monitoring through Sentinel 2/MSI data

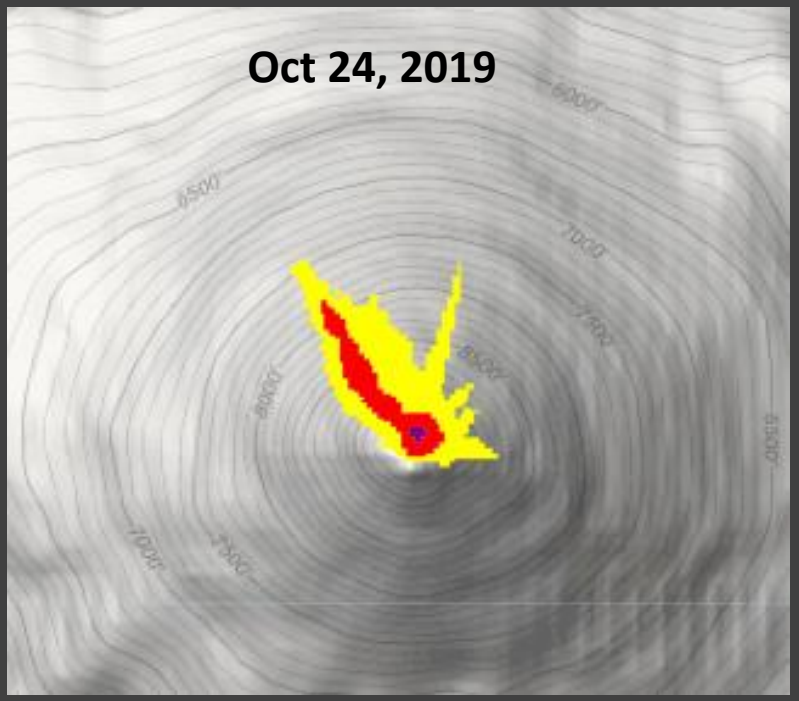


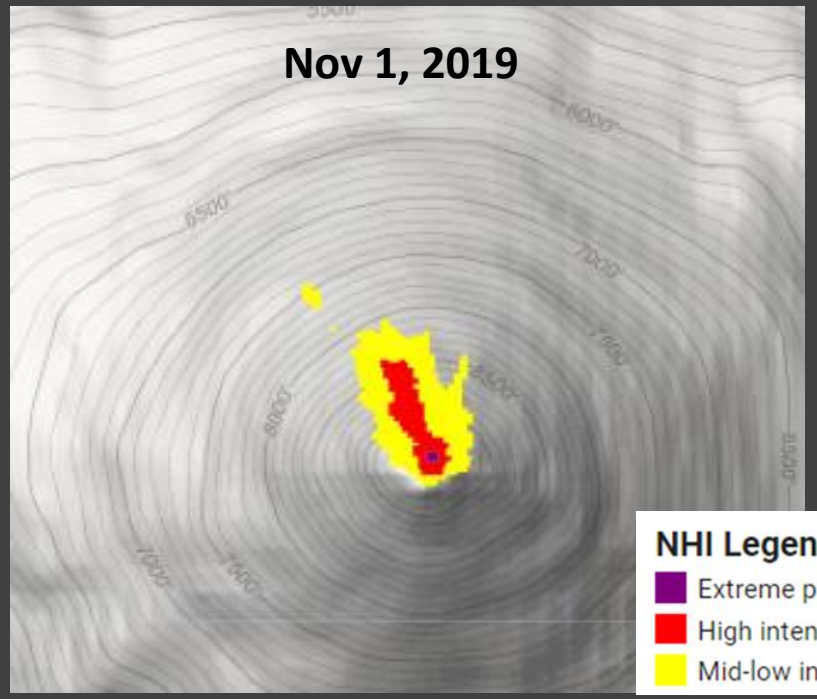


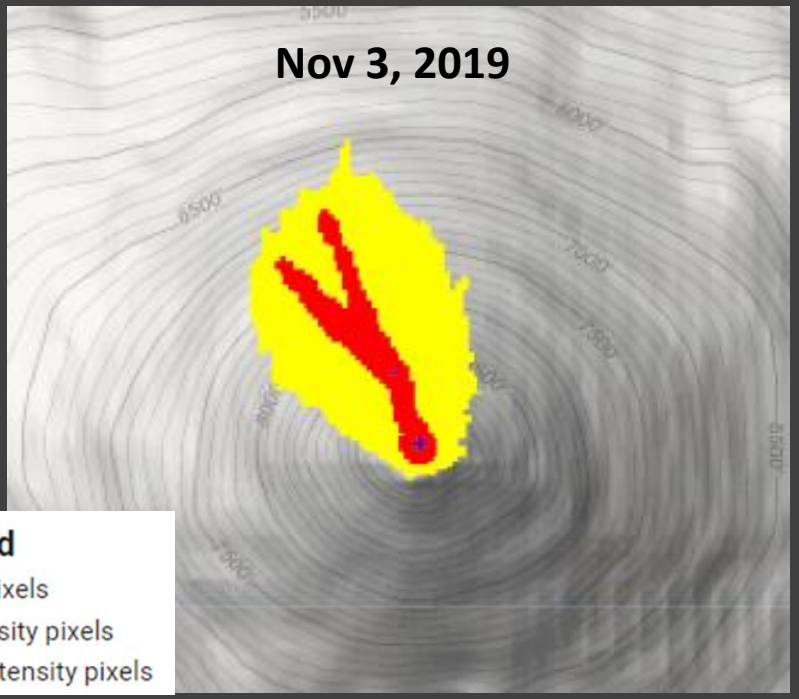

"New lava extrusion was observed on 13 October ... Lava had filled the crater by the 23rd and began to overflow at two places. One lava flow to the north reached a distance of 200 m on the 24th and melted snow to form a 2.9-km-long lahar down the N flank."

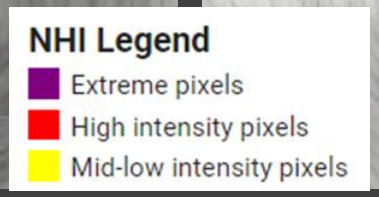
Global Volcanism Program, 2020. Report on Shishaldin (United States) (Krippner, J.B., and Venzke, E., eds.). *Bulletin of the Global Volcanism Network*, 45:2. Smithsonian Institution.



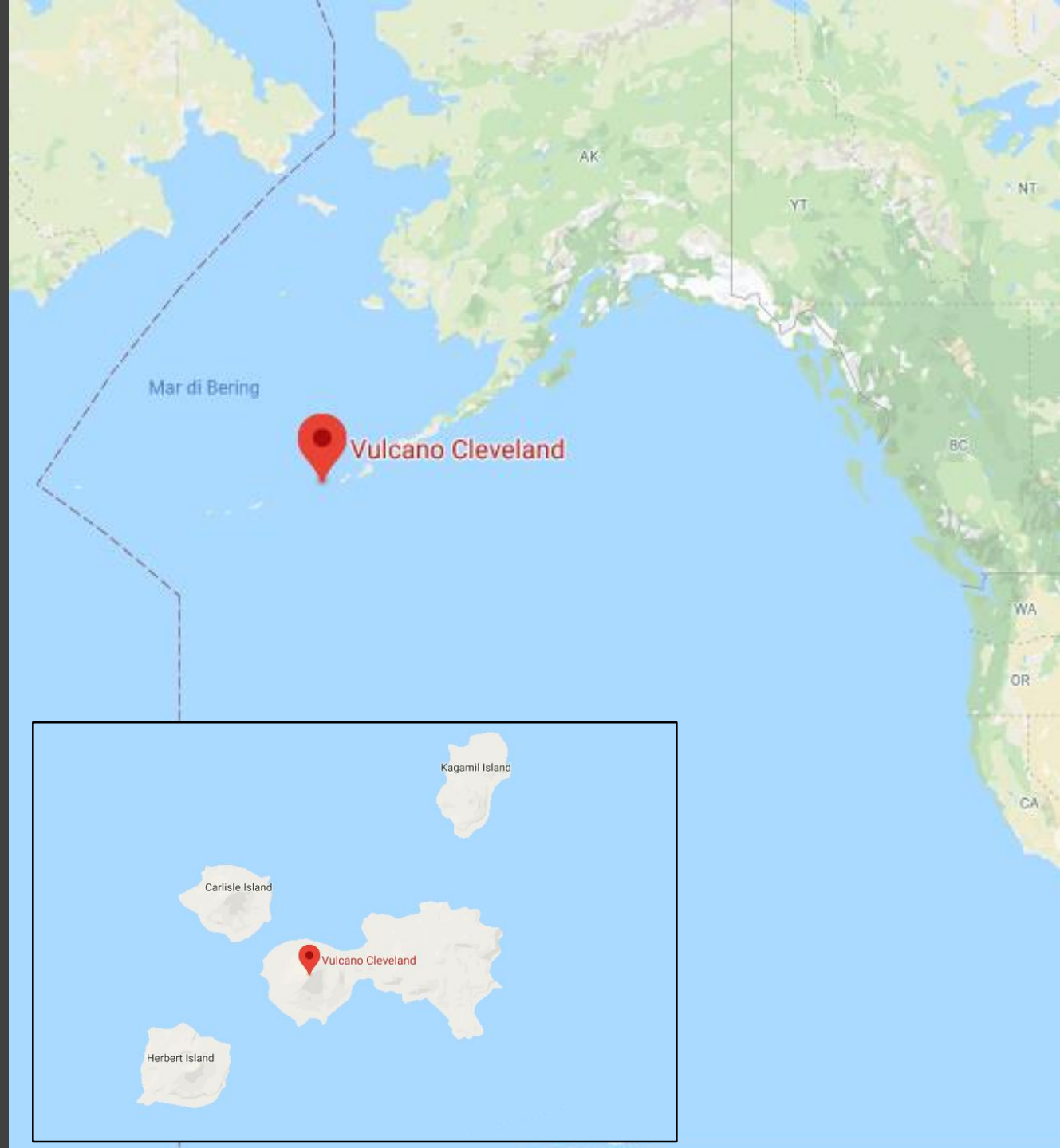



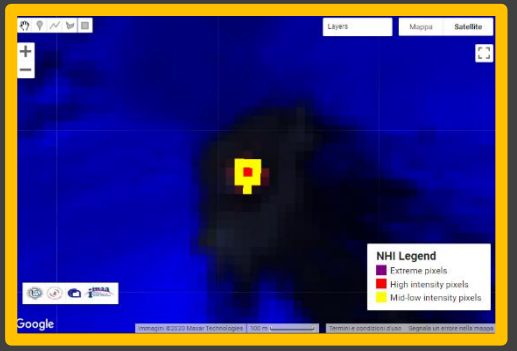



# Example 2
# *Mount Cleveland (lava dome)*

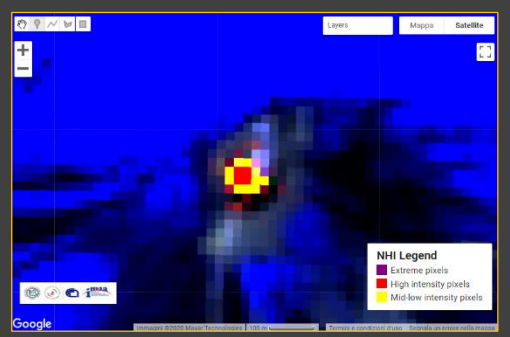
Cleveland
United States
52.825°N, 169.944°W



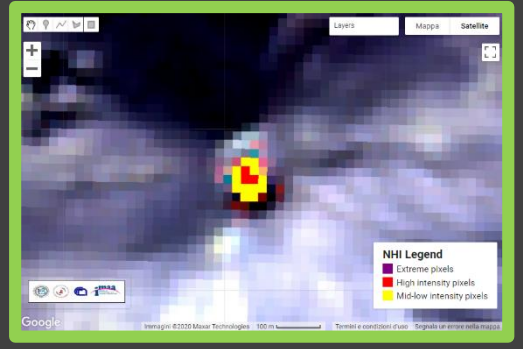
# Sentinel 2/MSI




Jun 7, 2018

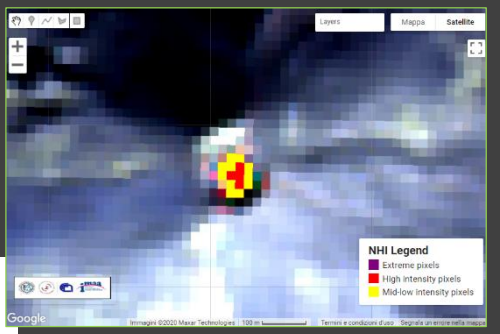



Jun 30, 2018

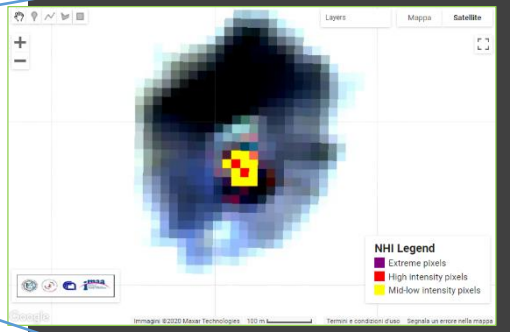



Sep 3, 2018

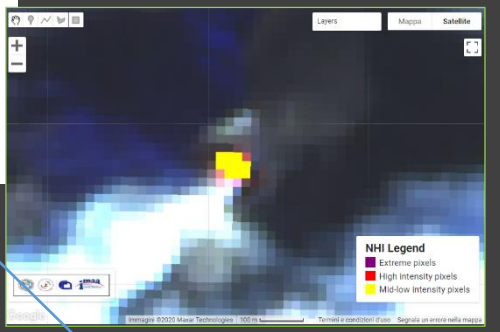

Sep 8, 2018



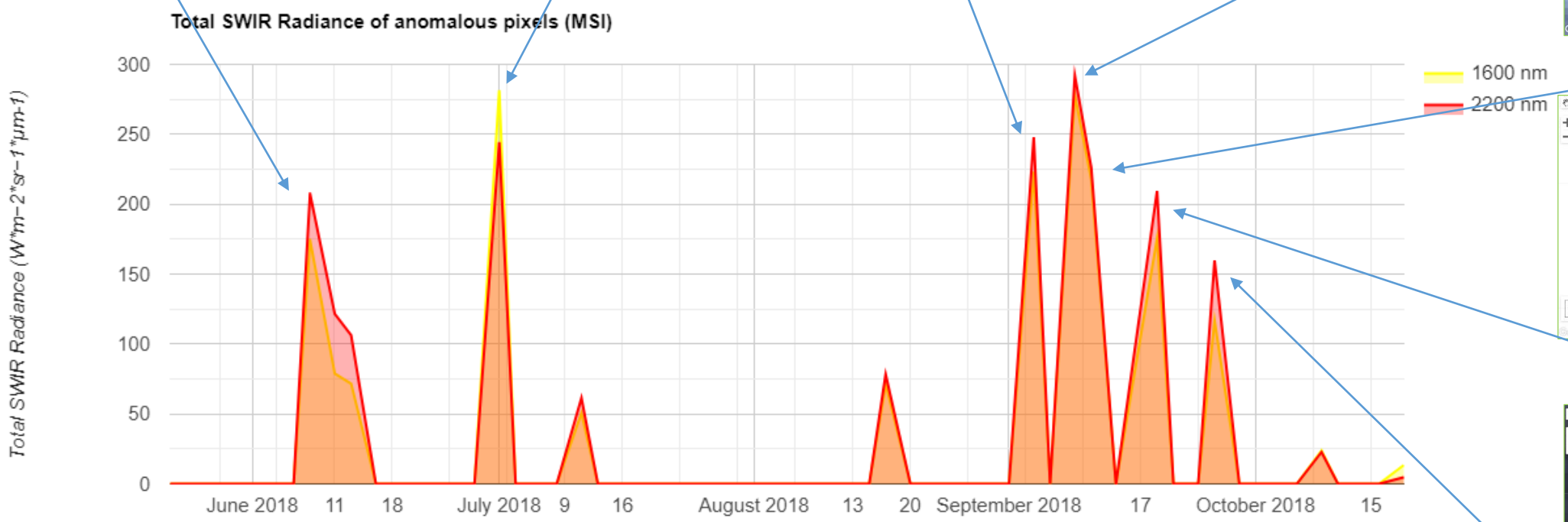

Sep 10, 2018




Sep 18, 2018




Sep 25, 2018




"… After evidence of a small lava dome on the floor of the summit crater appeared in late June 2018, weakly elevated surface temperatures were observed intermittently during July. …" **FIRST NHI DETECTION on June 7, 2018**

" … An unobscured satellite view on 10 September (figure 27) showed the first evidence of an emplaced lava dome within the crater. …" **FIRST NHI DETECTION on September 3, 2018**

Bulletin of the Global Volcanism Network, 44:2. Smithsonian Institution. https://doi.org/10.5479/si.GVP.BGVN201902-311240

# Conclusions

- The NHI tool is the only system which currently enables the interactive analysis of both Landsat 8/OLI and Sentinel 2/MSI data to investigate and map volcanic thermal anomalies.
- The NHI tool allows users (without any authentication) to generate thermal anomaly products over the volcanic area of interest (i.e. by a list of 1400 active volcanoes) in a few seconds/minutes, thanks to the high computational capabilities of GEE.
- These performances make the NHI tool suited to contribute to the surveillance of active volcanoes from space.

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# Work in progress

- Possible ingestion into the NHI tool of:
  - Data collection from prior sensors (i.e. TM, ETM+, ASTER) to extend the temporal range of satellite data analyses, making available to users more than 30 years of thermal anomaly products.
  - Data collection from current sensors (e.g. VIIRS) to increase the frequency of observations at the monitored volcanic areas.
- Development of new functions aiming at:
  - better integrating data from different sensors.
  - increasing the user-friendly experience.
- Customization of the NHI tool to investigate and map other hot targets:
  - gas flaring activity.
  - forest fires.
  - …

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# Work in progress ... lava flows of the Etna (Italy) volcano on December 30, 2002 by means ETM+ and ASTER