

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 [$\text{W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1} \cdot \text{m}^{-1}$] 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 $NHI_{SWNIR} > 0$ are used to detect volcanic hotspots.

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

The screenshot shows the NHI Tool for volcanoes (v1.3) interface. The browser address bar displays the URL: nicogenzano.users.earthengine.app/view/nhi-tool. The interface includes a search bar, a map of Europe and the Mediterranean region, and a control panel with the following sections:

- NHI Tool for volcanoes (v1.3)**

This tool enables the investigation of volcanic thermal anomalies from Landsat 8 and Sentinel 2 collections using the NHI (Normalized Hotspot Indices) algorithm (Marchese et al, 2019)

[How to use the tool](#)
- 1) Select volcano**

(More than 1400 Holocene volcanoes listed by the Global Volcanism Program; [Click here for the list of recent activities](#))

Choose a volcano... ▾
- 2) Select period**

Start date (YYYY-MM-DD)

End date (YYYY-MM-DD)
- 3) Define distance buffer**

(After writing the distance, max 31.000 m for OLI - 20.000 m for MSI, press ENTER for a preview of the investigated area)

Distance in meters

The map shows a satellite view of Europe and the Mediterranean region, with various countries labeled. The interface also includes a search bar, a map control panel, and a Google logo.

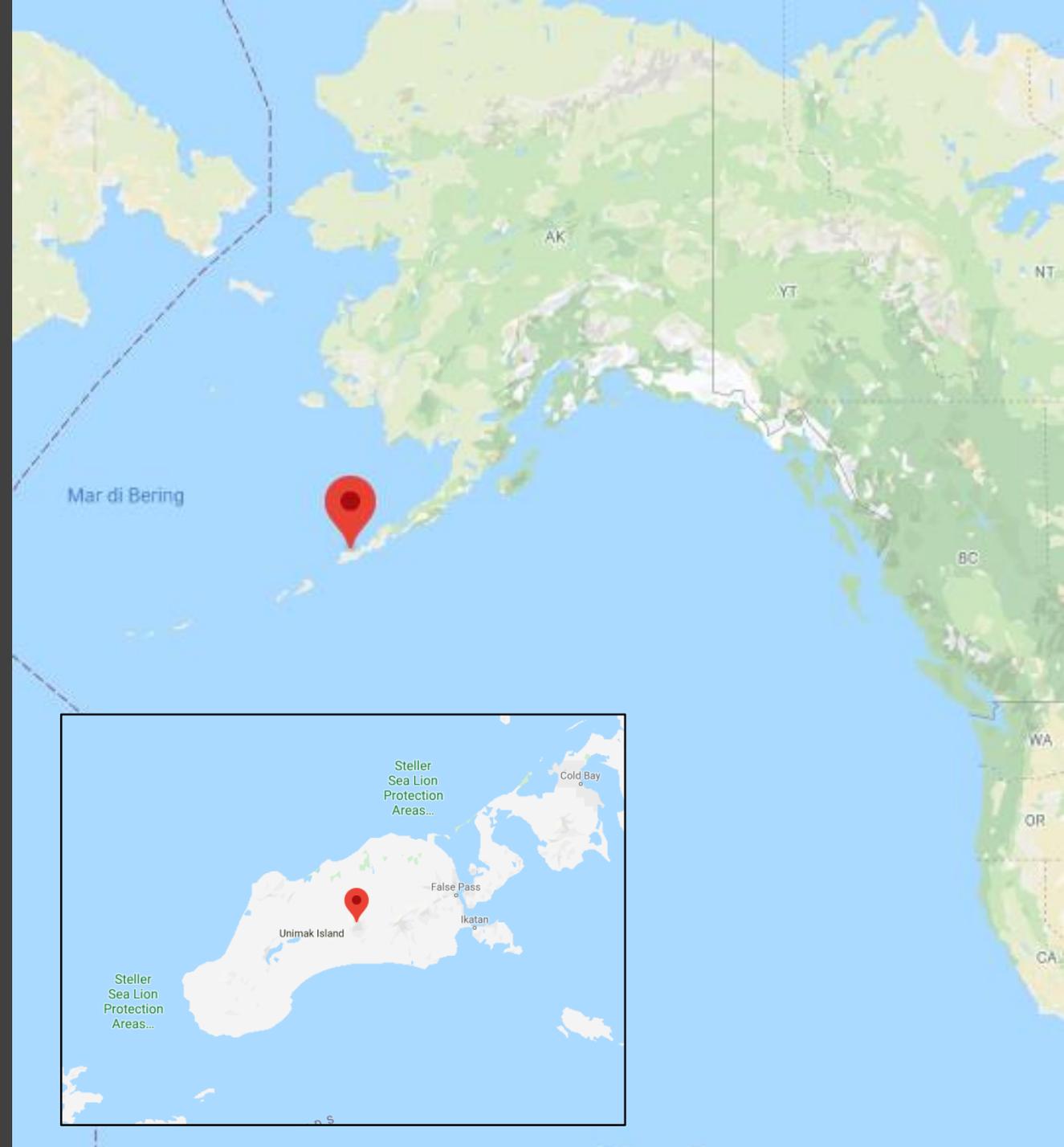
<https://nicogenzano.users.earthengine.app/view/nhi-tool>

Example 1

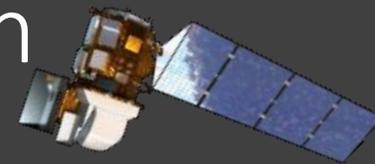
Shishaldin

(lava flows)

Shishaldin
United States
54.756°N, 163.97°W

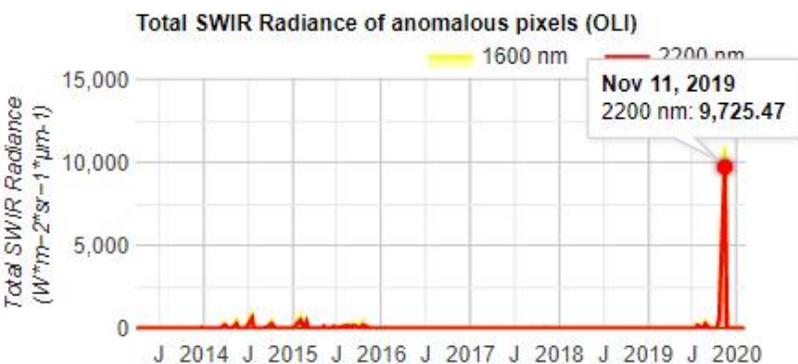
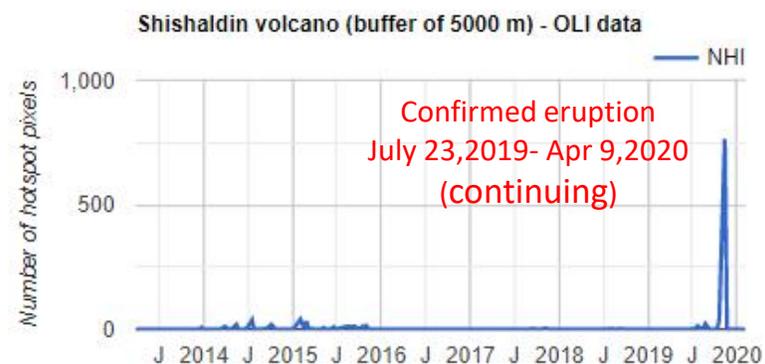


Shishaldin volcano long-term observation performed using Landsat 8/OLI data



Google Earth Engine

Search places and datasets...



Nov 11, 2019



Google

Layers

Mappa

Satellite

OLI image (RGB: B7-B6-B5 Reflectance) visualization parameters

1 band (Grayscale) 3 bands (RGB)

B7 B6 B5

Range

5944.4 - 8022.6 Custom

Opacity

Gamma Palette

1.00 0.96

Import Apply Close

NHI Legend

- Extreme pixels
- High intensity pixels
- Mid-low intensity pixels

4) Select a Landsat 8 image to visualize

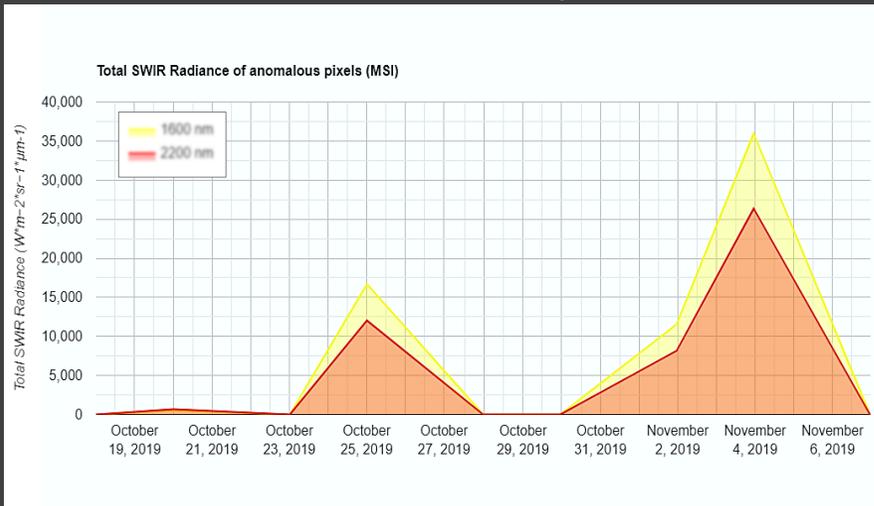
LC08_076022_20191111

Immagini ©2020 TerraMetrics 1 km

Termini e condizioni d'uso Segnala un errore nella mappa

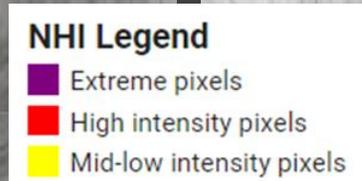
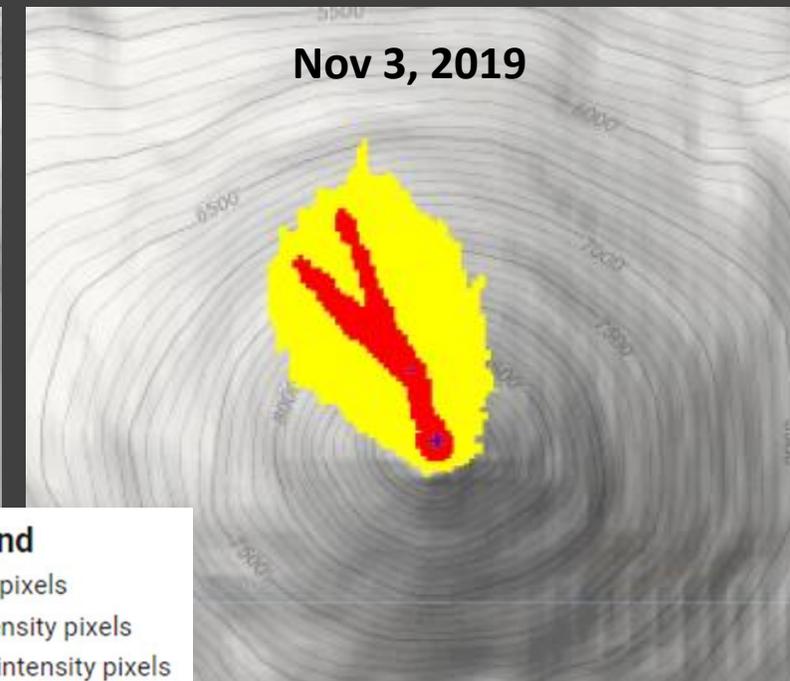
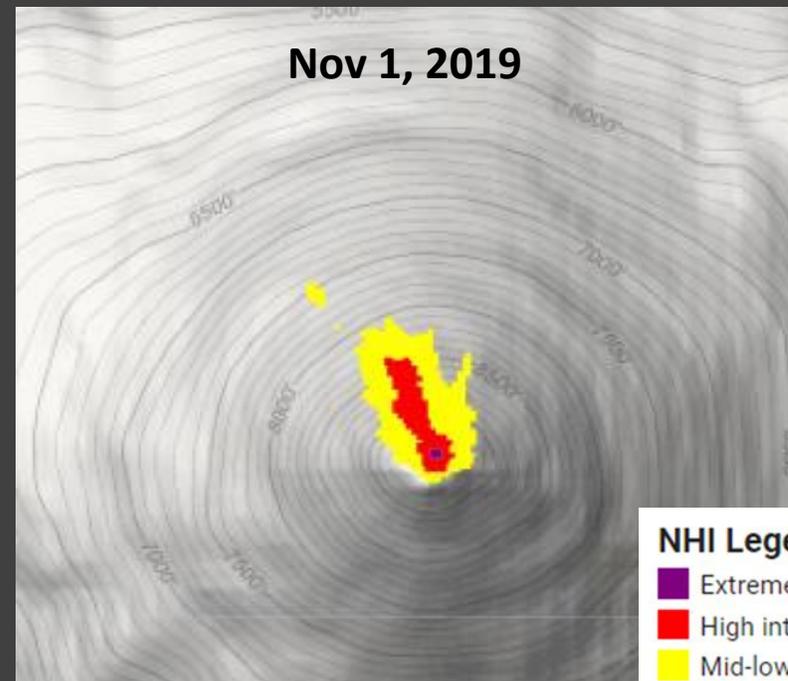
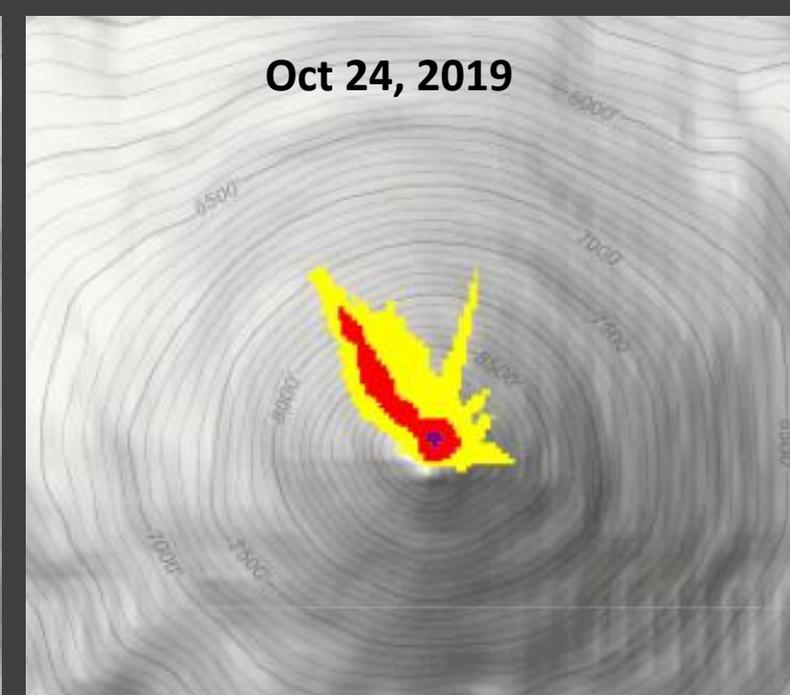
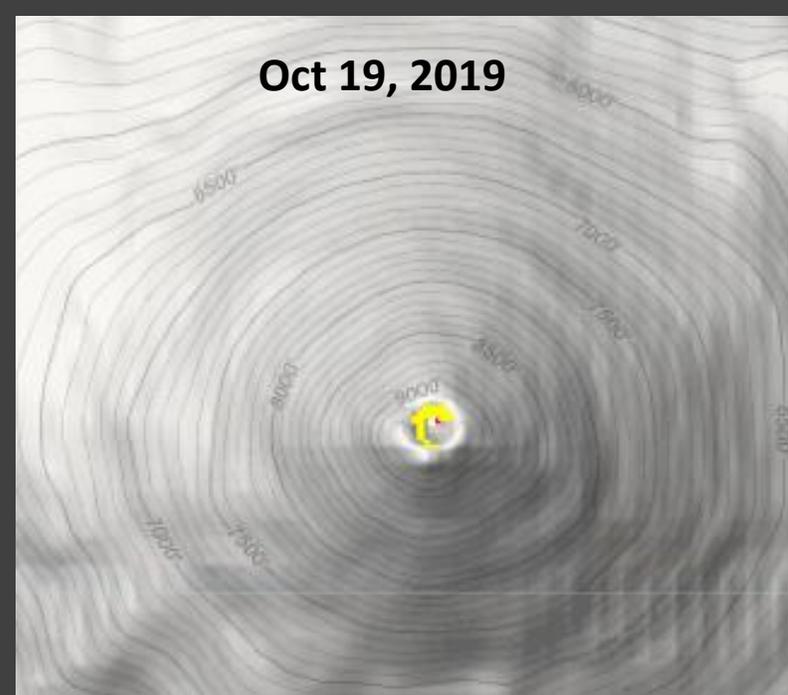
Shishaldin

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.”

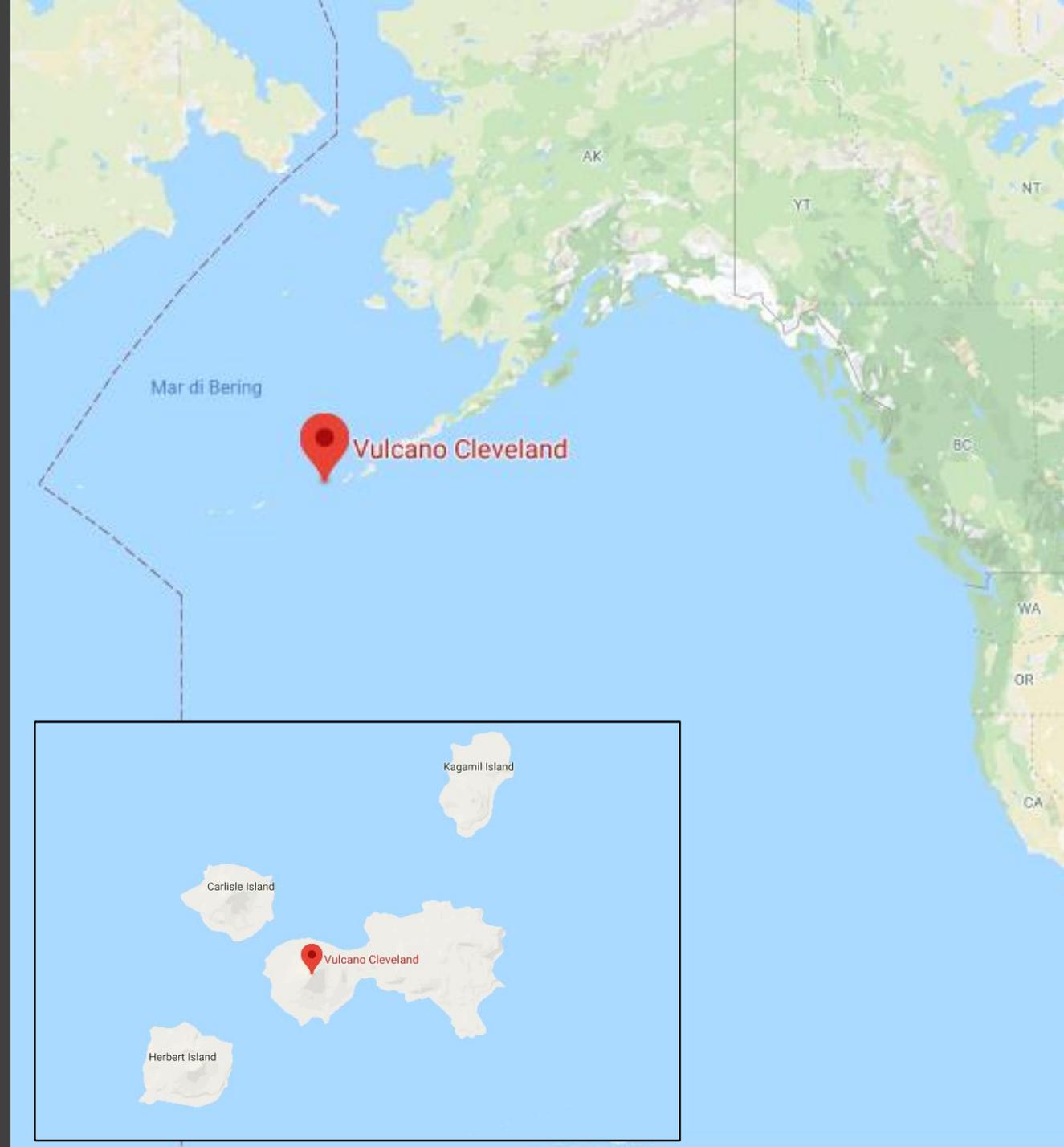
Global Volcanism Program, 2020. Report on Shishaldin (United States) (Krippner, J.B., and Venzke, E., eds.). *Bulletin of the Global Volcanism Network*, 45:2. Smithsonian Institution.



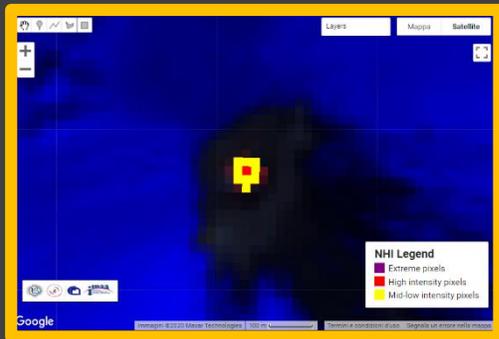
Example 2

Mount Cleveland *(lava dome)*

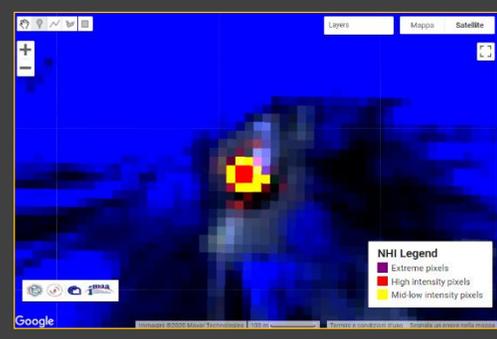
Cleveland
United States
52.825°N, 169.944°W



Sentinel 2/MSI



Jun 7, 2018



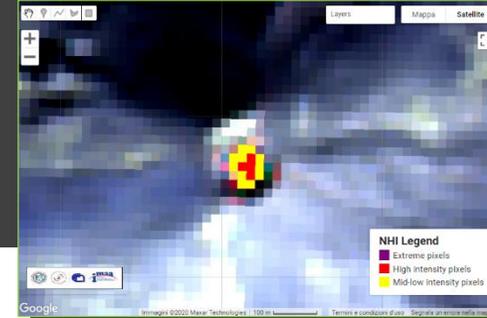
Jun 30, 2018



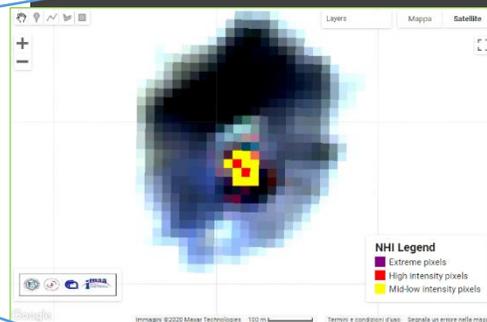
Sep 3, 2018



Sep 8, 2018



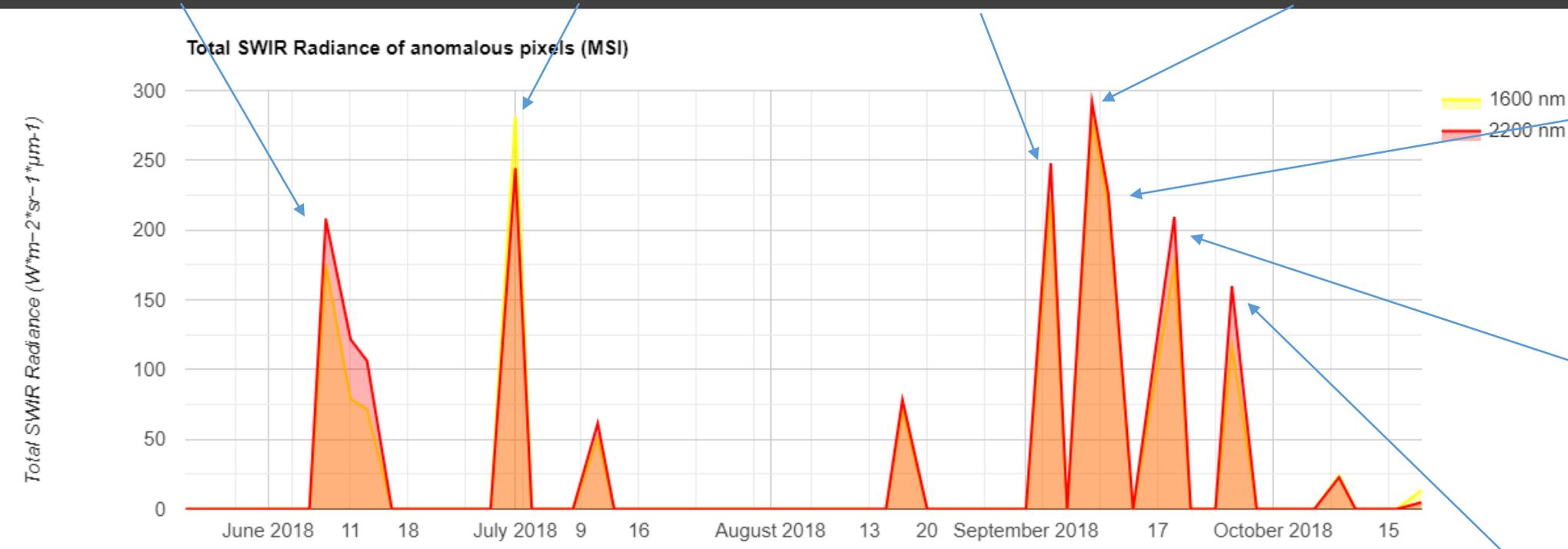
Sep 10, 2018



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**

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.

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.
 - ...

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

Google Earth Engine

Search places and datasets...

1) Select volcano

Etna

2) Select period

Start date (YYYY-MM-DD)

1999-05-01

End date (YYYY-MM-DD)

2020-04-28

3) Define distance buffer

(max 31.000 m for OLI; 20.000 m for MSI)

20000

Start NHI analysis

Use of the data

TERRA/ASTER - December 30, 2002 10:00

LANDSAT 7/ETM+ - December 30, 2002 09:30