Applications of UAS thermal infrared cameras to volcanic and geothermal processes

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NASA ESI & ESTO UAS Workshop

EAR PF Award
#1725768

Einat Lev
Theresa Sawi

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

Christopher Edwards

Northern Arizona University

Adam Soule

Woods Hole Oceanographic Institution

Kristen Bennett
Greg Vaughan
Matt Patrick

USGS science for a changing world

Silvia Vallejo Vargas

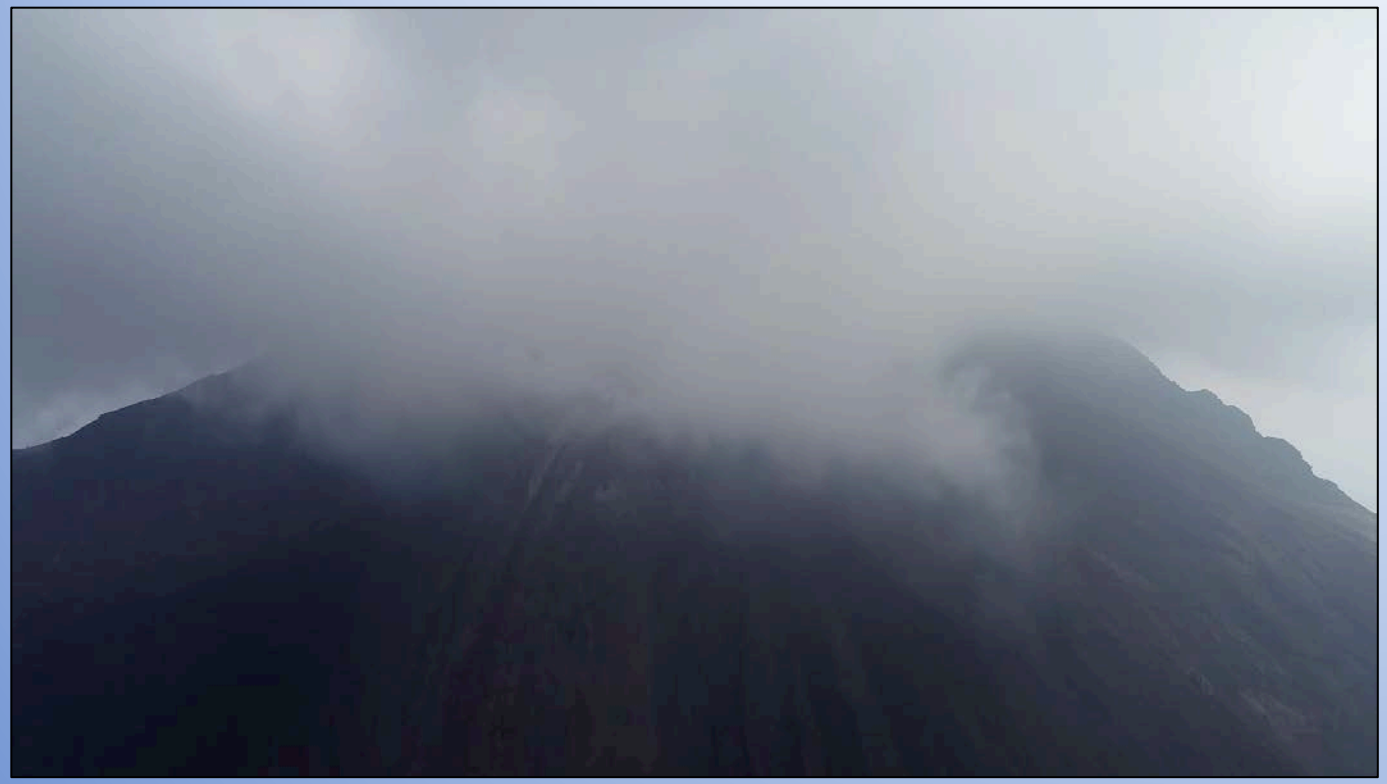
IG Instituto Geofísico
Escuela Politécnica Nacional

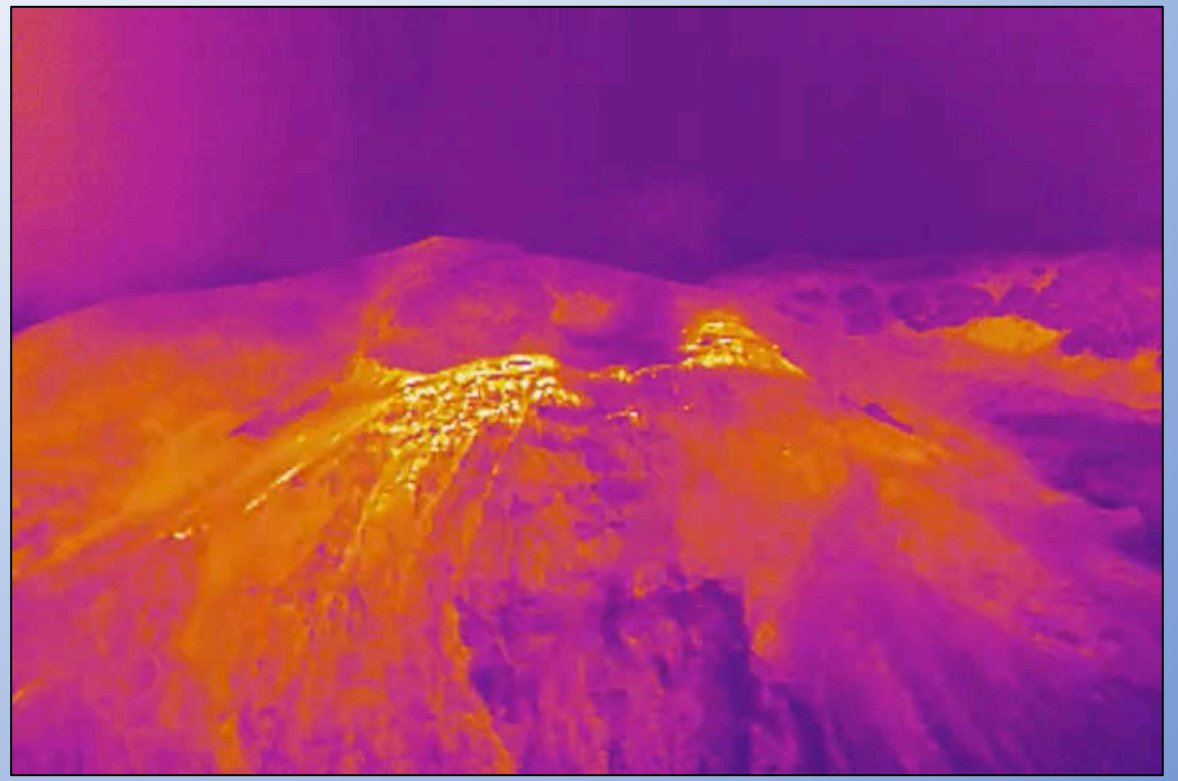
Ryan Perroy,
SDAV Lab

University of Hawai'i

Why Thermal?

Thermal can see what visual can’t

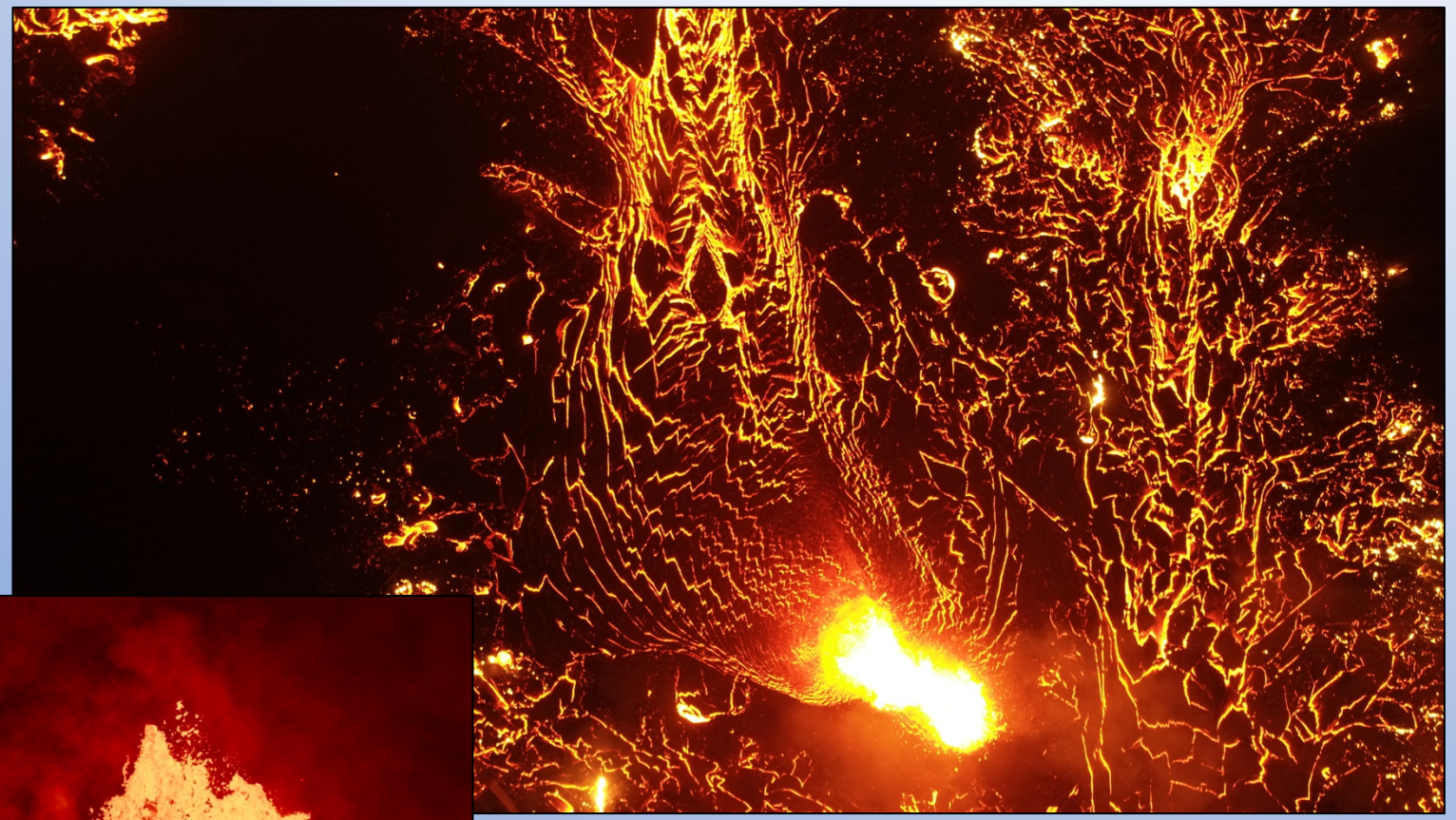


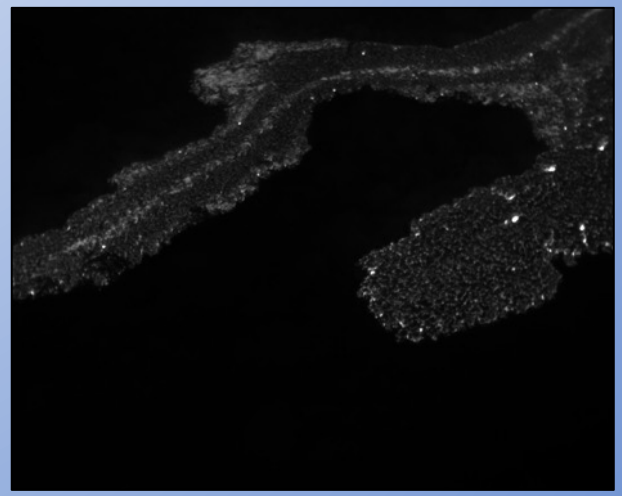


Stromboli (Italy)

Why UAS?

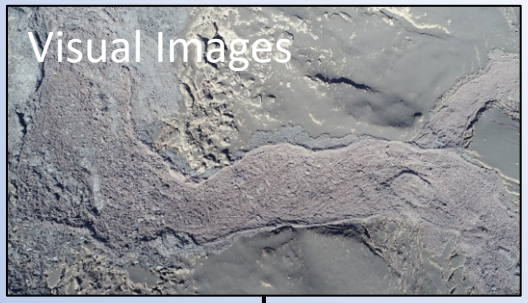
Ability to fly where and when crewed aircraft cannot

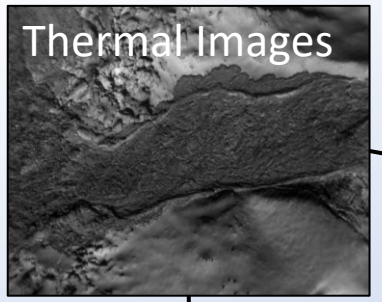




Kīlauea 2018

Thermal images can be used for SfM Photogrammetry





Convert between Radiometric temperature and Digital Number

Structure-from-Motion Photogrammetry (Agisoft Metashape Pro)

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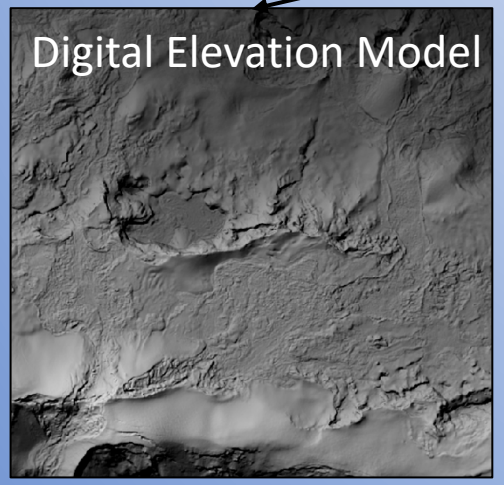
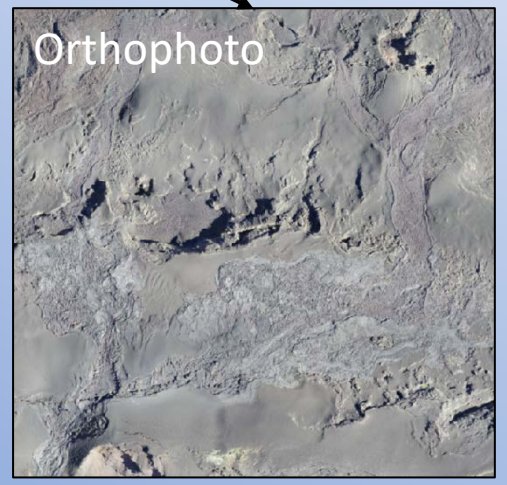
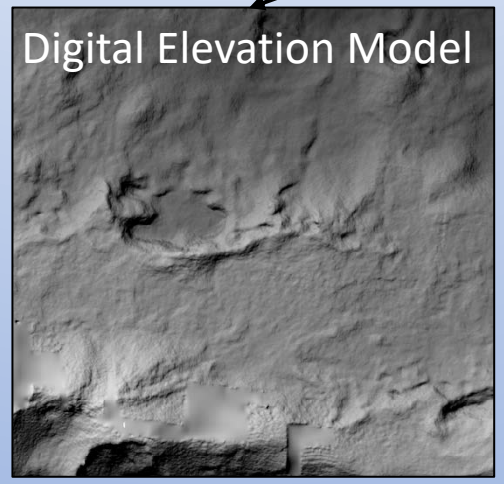
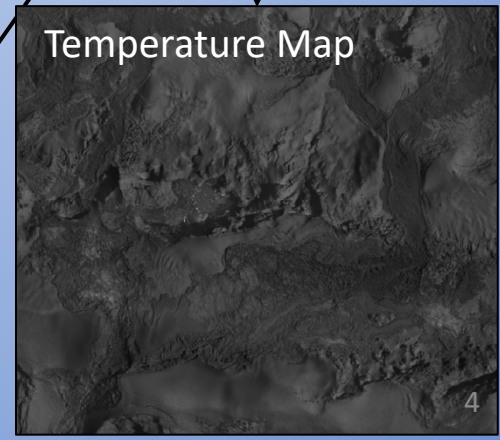


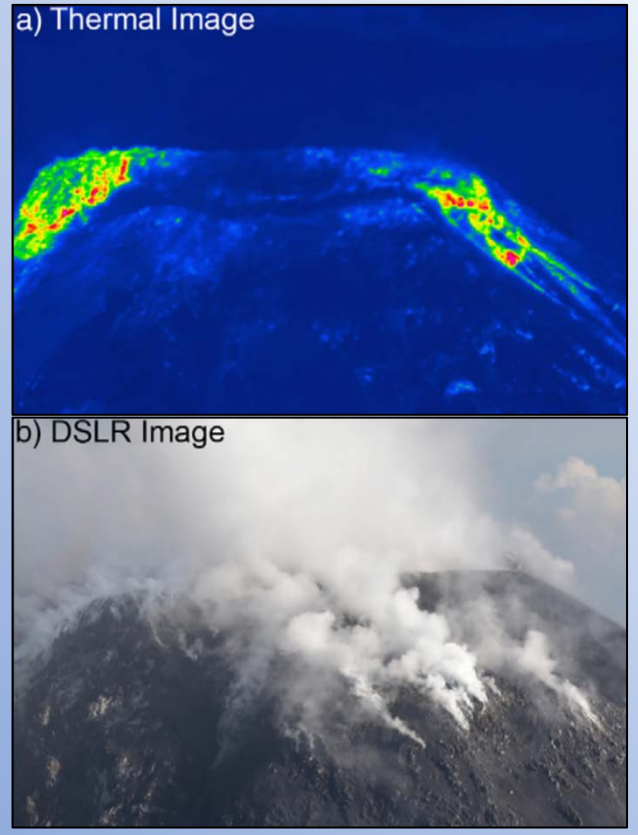






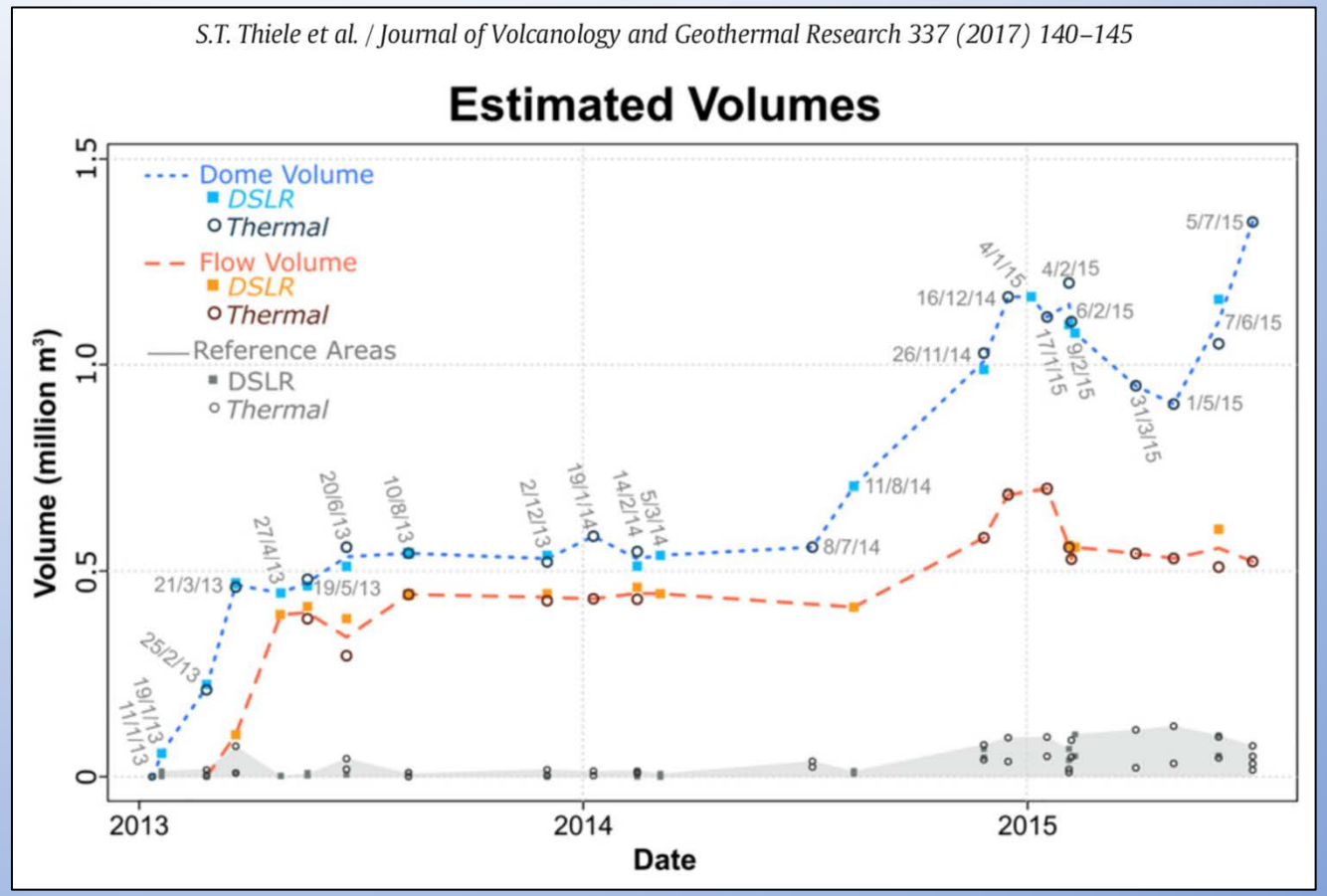
RESOLUTION: 0.08 m 0.04m 0.76m 0.19m

Applications of TIR-derived DEMs



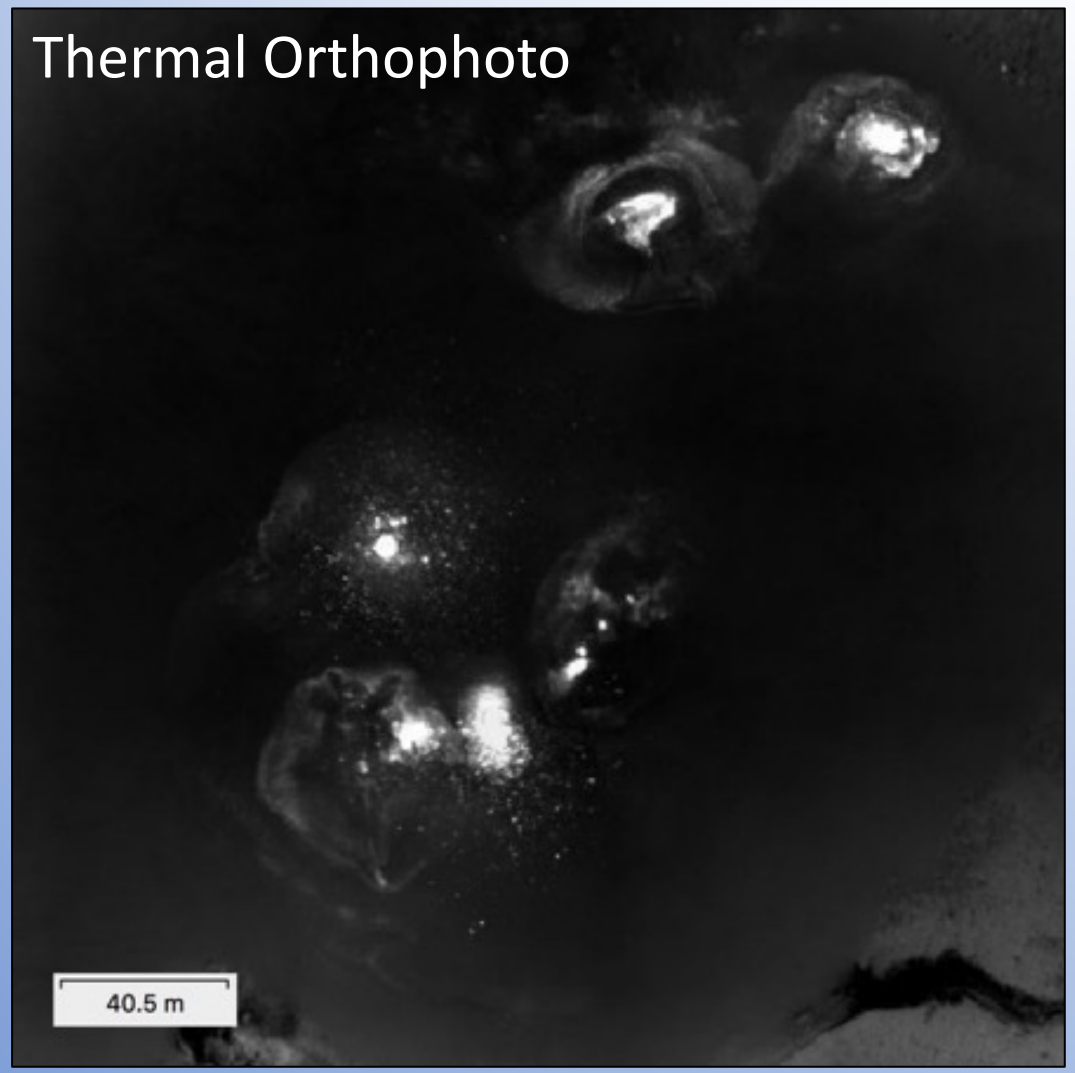
Colima (Mexico)

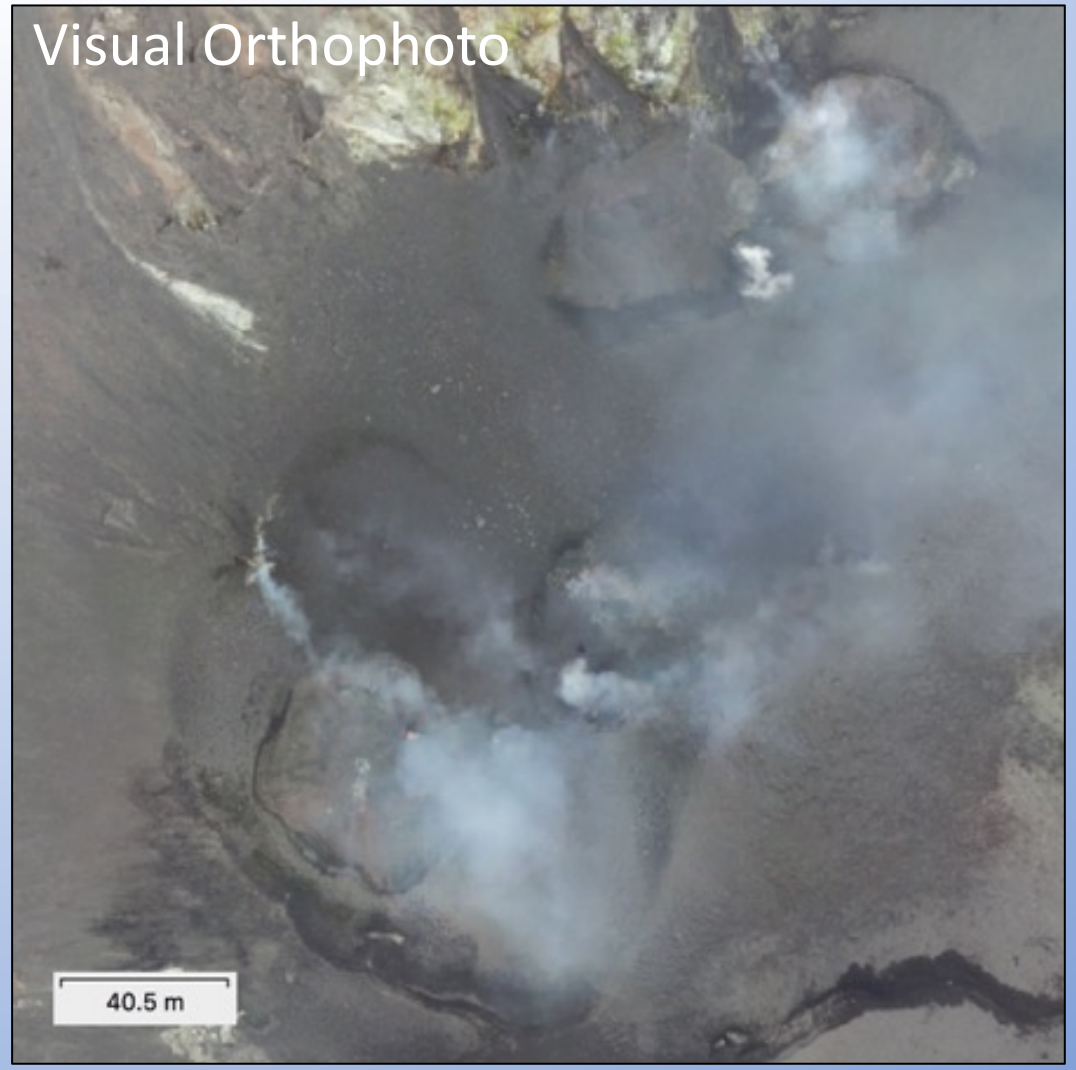
Volume change over time



Thiele et al., 2017: “Thermal photogrammetric imaging: A new technique for monitoring dome eruptions”

Applications of uncalibrated thermal orthophotos





Stromboli (Italy)

Applications of Temperature Maps: Heat Flux

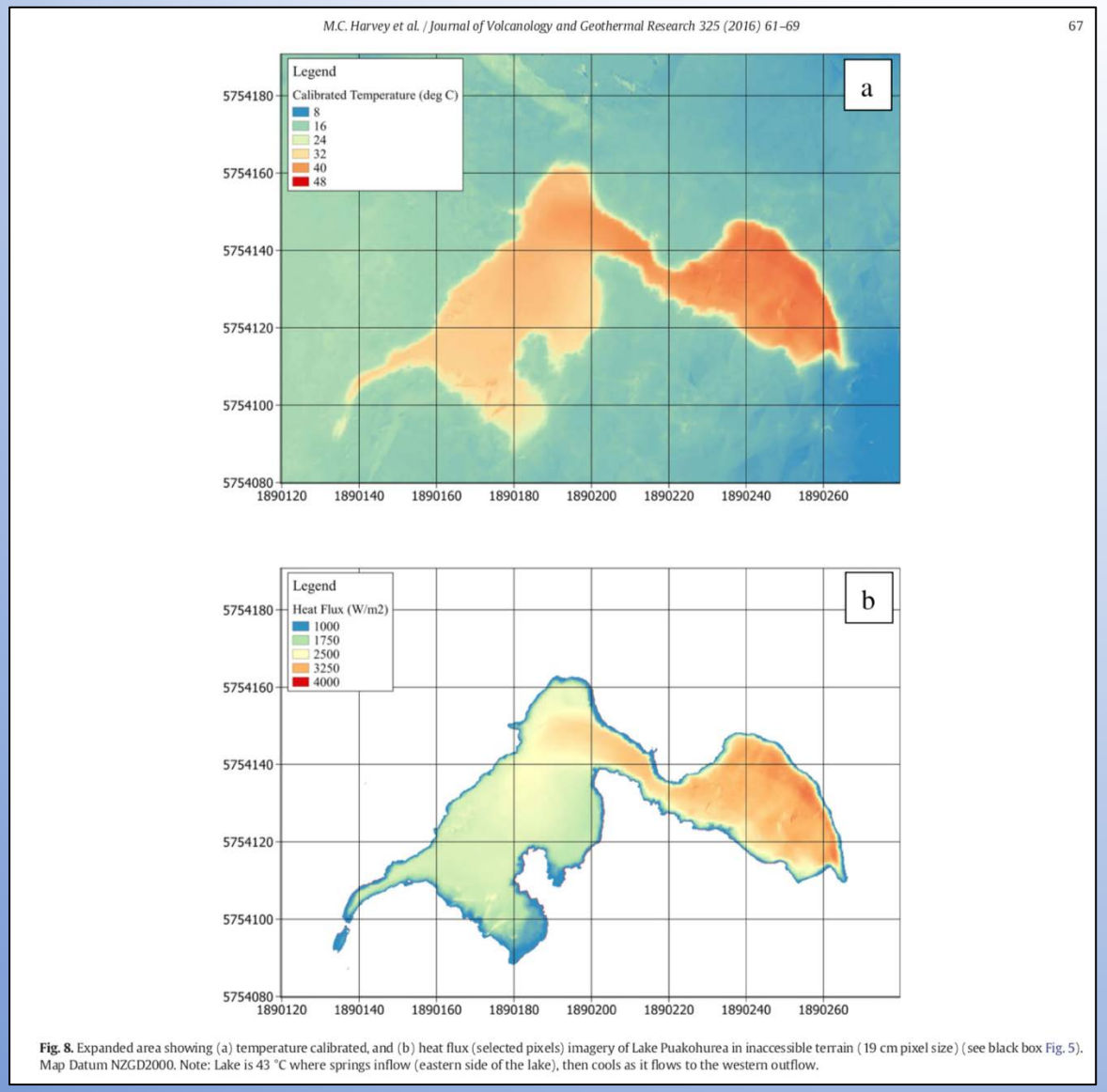


Fig. 8. Expanded area showing (a) temperature calibrated, and (b) heat flux (selected pixels) imagery of Lake Puakohurea in inaccessible terrain (19 cm pixel size) (see black box Fig. 5). Map Datum NZGD2000. Note: Lake is 43 °C where springs inflow (eastern side of the lake), then cools as it flows to the western outflow.

Thermal budgets of hydrothermal features/systems

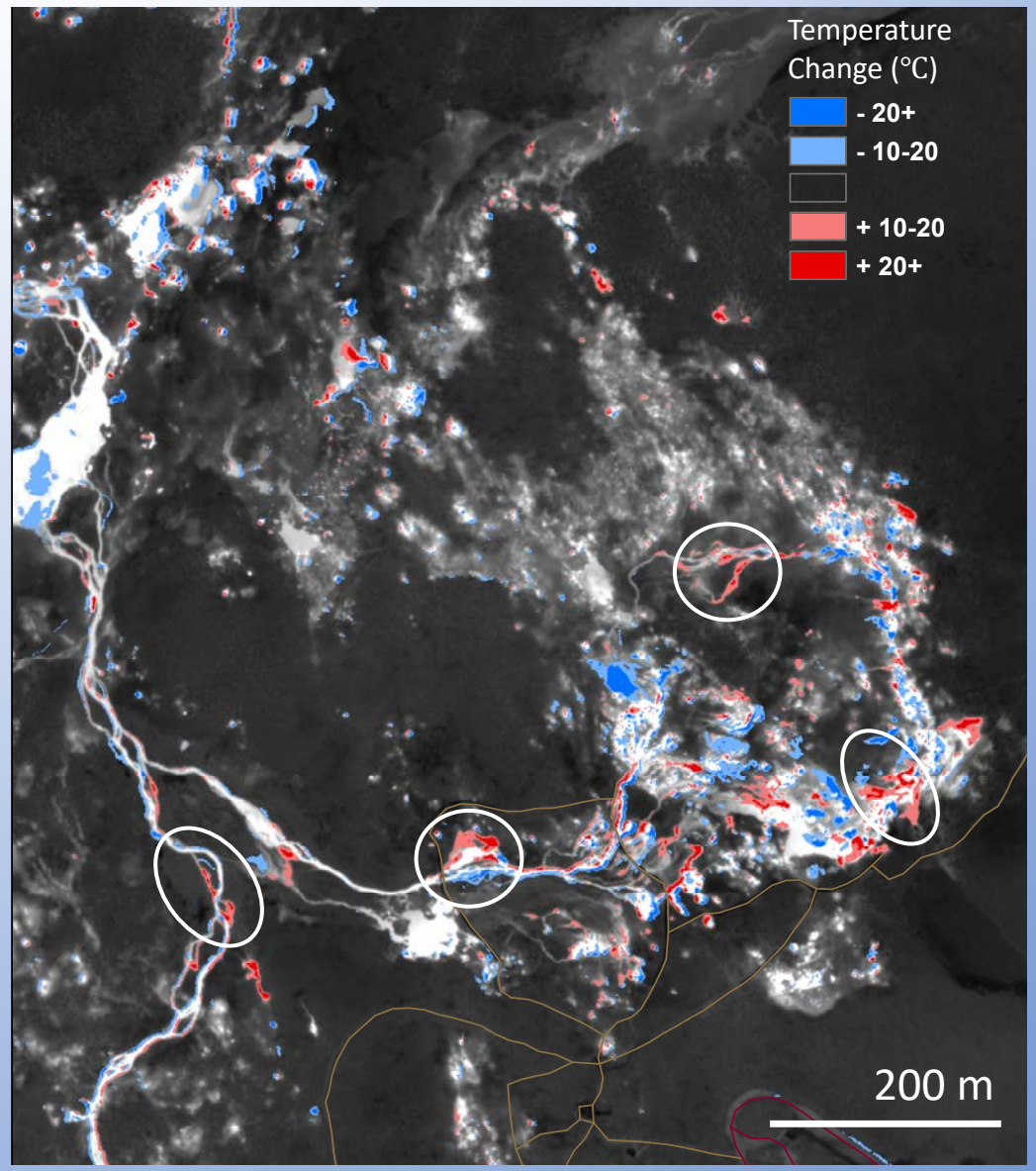
Harvey et al., 2016

"Drone with thermal infrared camera provides high resolution georeferenced imagery of the Waikite geothermal area, New Zealand"

Applications of Temperature Maps: Change

Change over 2 Years (April 2013 to March 2015)

1. **Changing hot spring outflow channels**
2. New features or features with increased activity
3. Features that ceased or decreased activity



Norris Geyser Basin (Porcelain Basin)
Yellowstone National Park

Carr & Vaughan, 2017, AGU Abstract NH31A-0203

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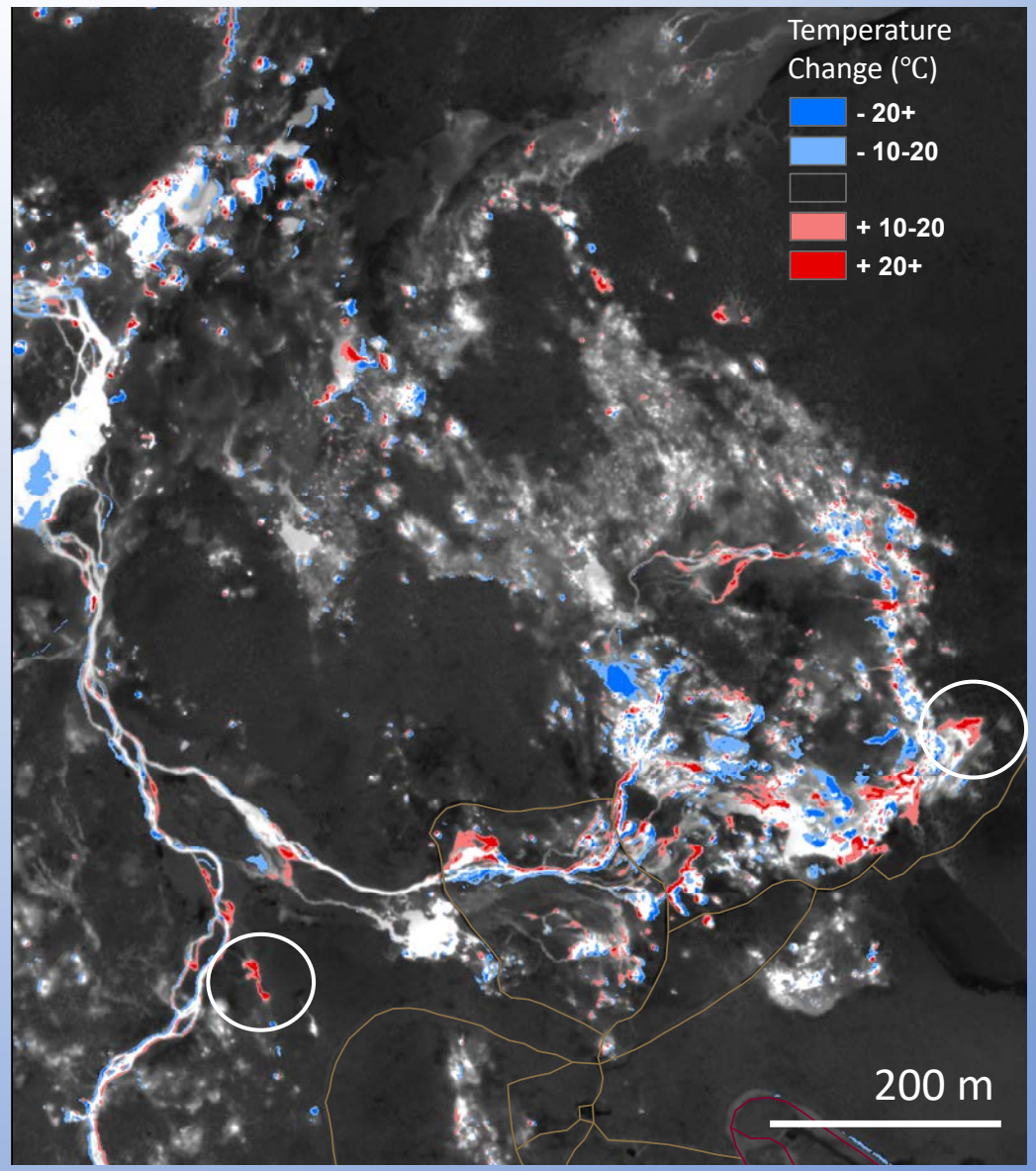

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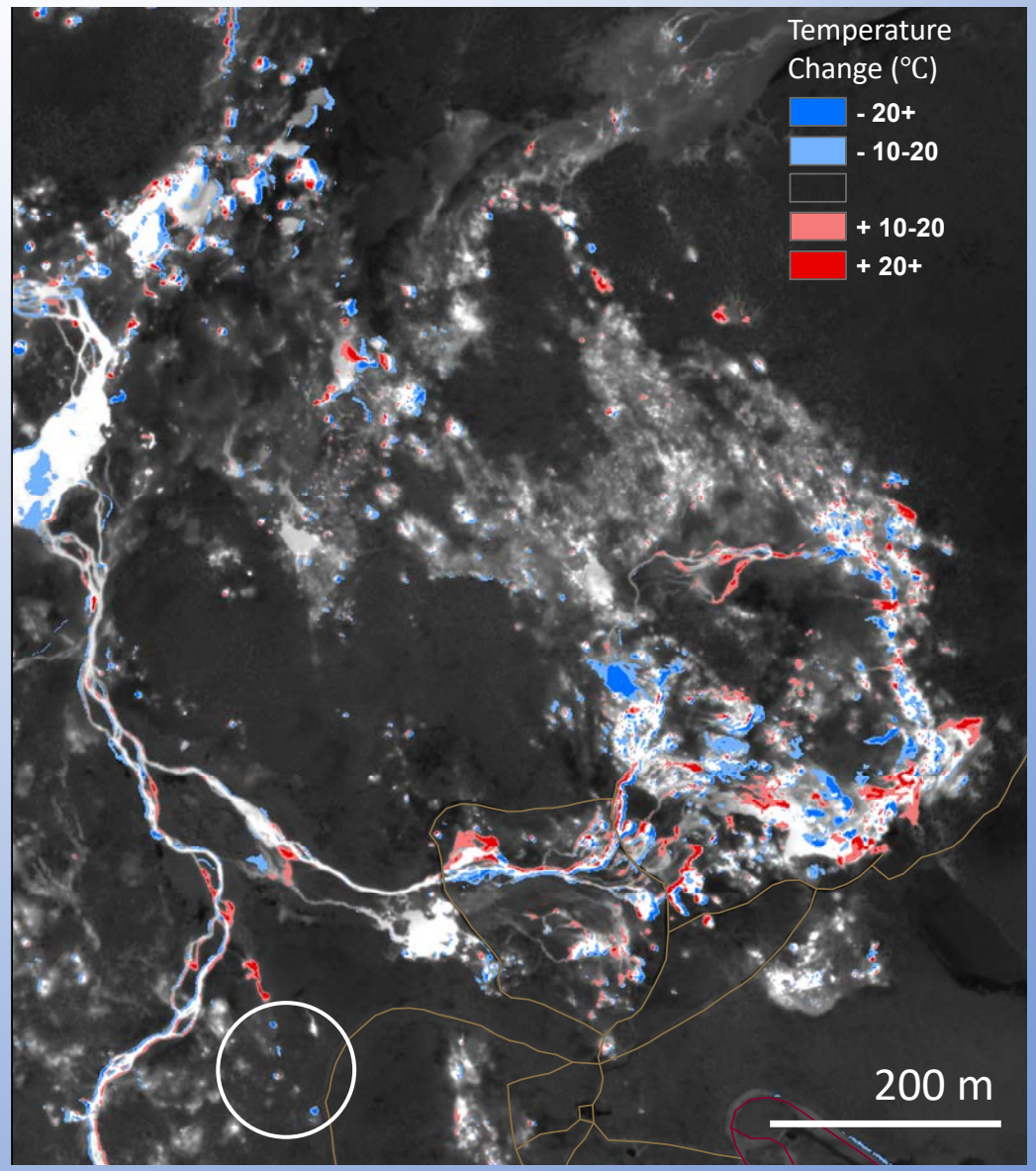

Norris Geyser Basin (Porcelain Basin)
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Carr & Vaughan, 2017, AGU Abstract NH31A-0203

Properties of Surfaces with Temperature Maps

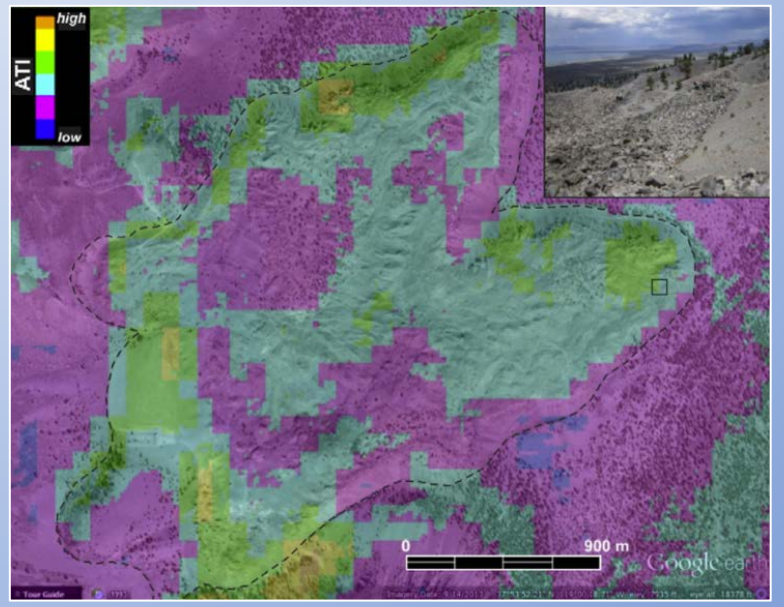
Different surfaces heat at different rates

Thermal Inertia:

a physical material property

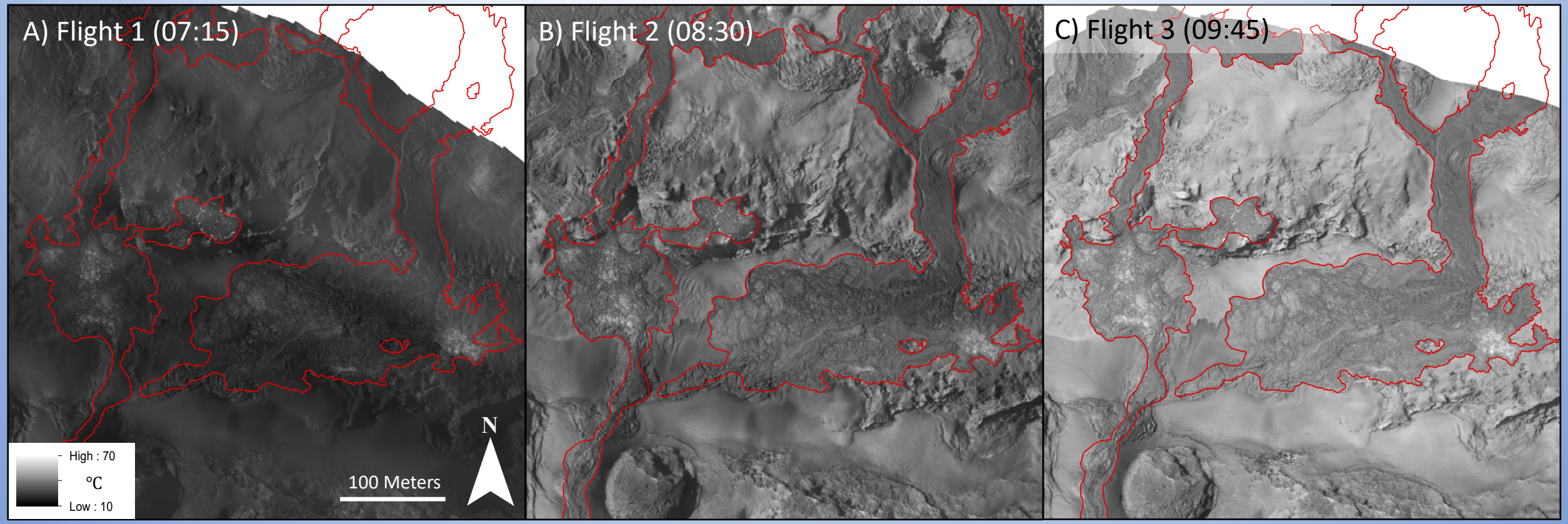
$$TI = \sqrt{k\rho c}$$

$$= \sqrt{thermal\ conductivity \times density \times specific\ heat}$$



Apparent Thermal Inertia (ASTER)
North Coulee Rhyolite, Mono Craters (CA)
Price et al. (2016; Ramsey et al. (2016)

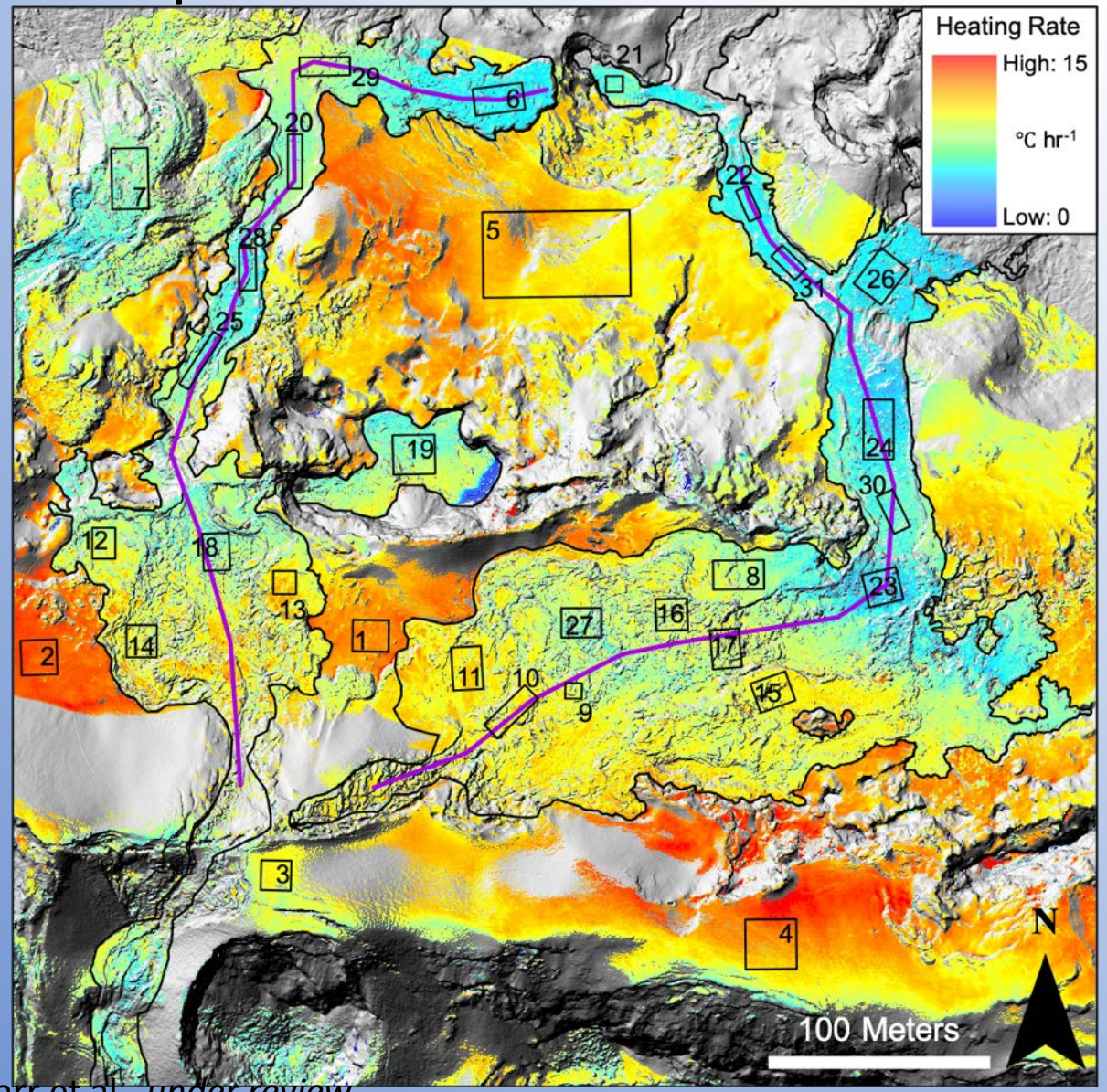
Properties of Surfaces with Temperature Maps



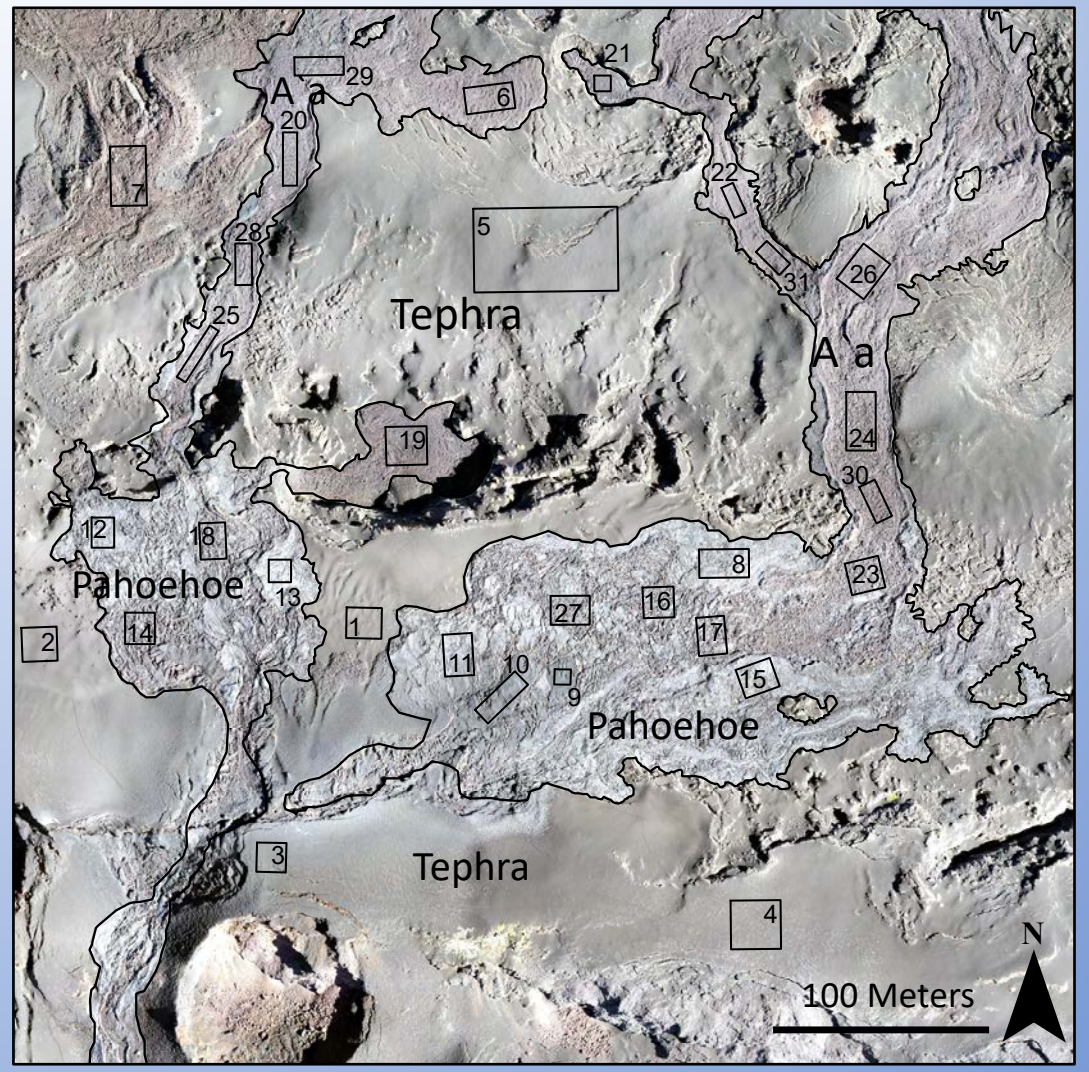
Time Series of temperature maps, Sierra Negra (Galapagos Islands)

Carr et al., *under review*

Properties of Surfaces with Temperature Maps



Visual Orthophoto



Carr et al., *under review*

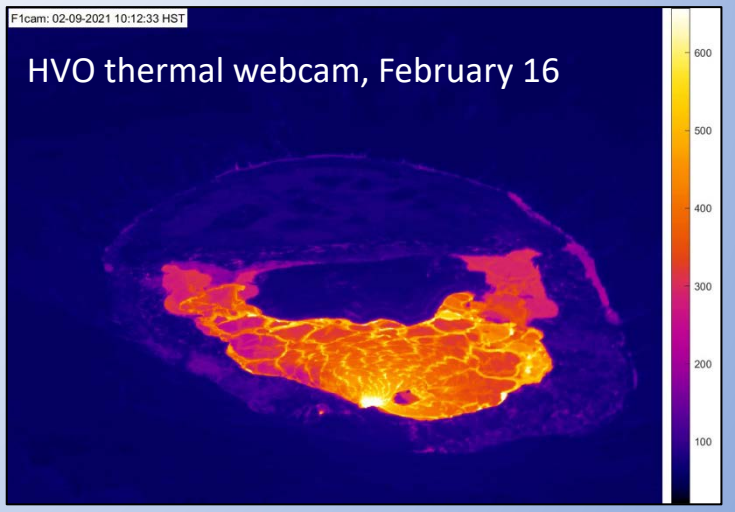
Properties of Surfaces with Temperature Maps

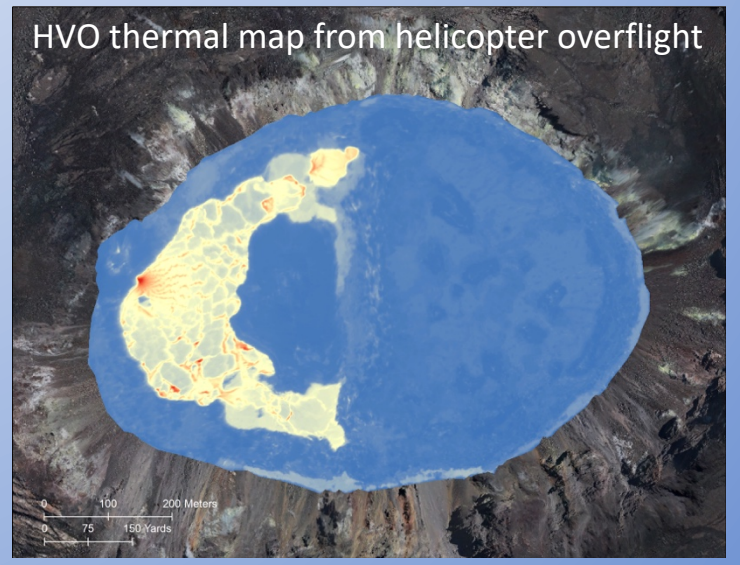
Broadly applicable to investigations of any surface where properties of gain size, density, and water content may vary

Future Directions:

Bridge the gap between satellite and ground-based TIR observations

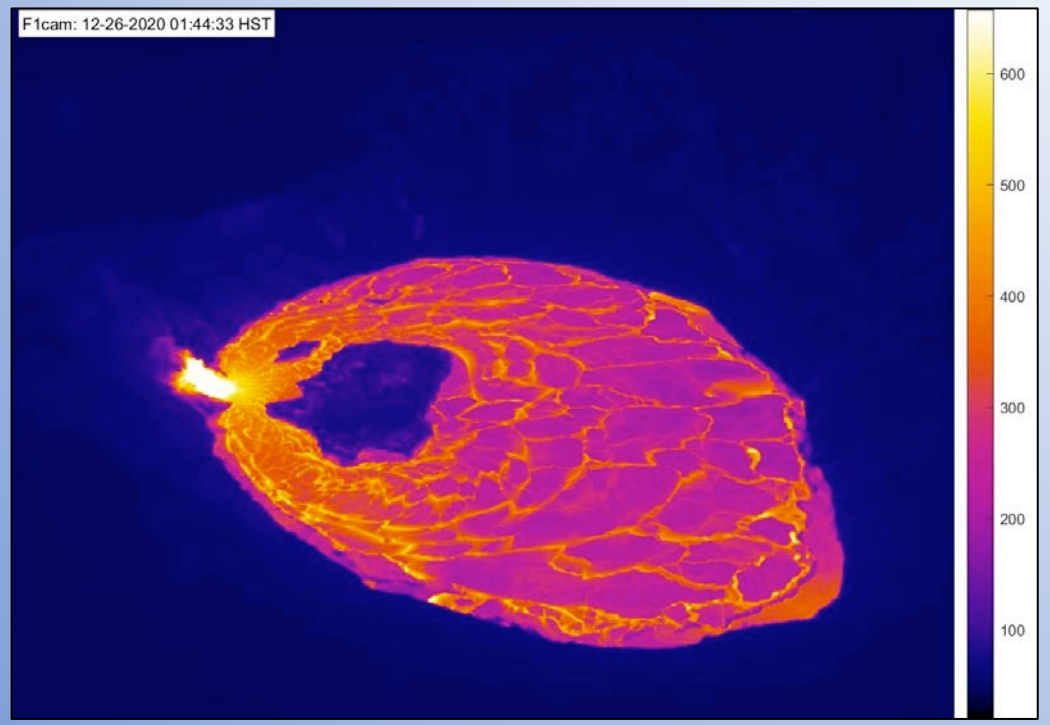
Kīlauea, December 21, 2020





Future Directions:

Take ground-based and satellite TIR techniques to UAS platforms



USGS-HVO Webcam, Halemaʻumaʻu crater, Kīlauea, December 26, 2020

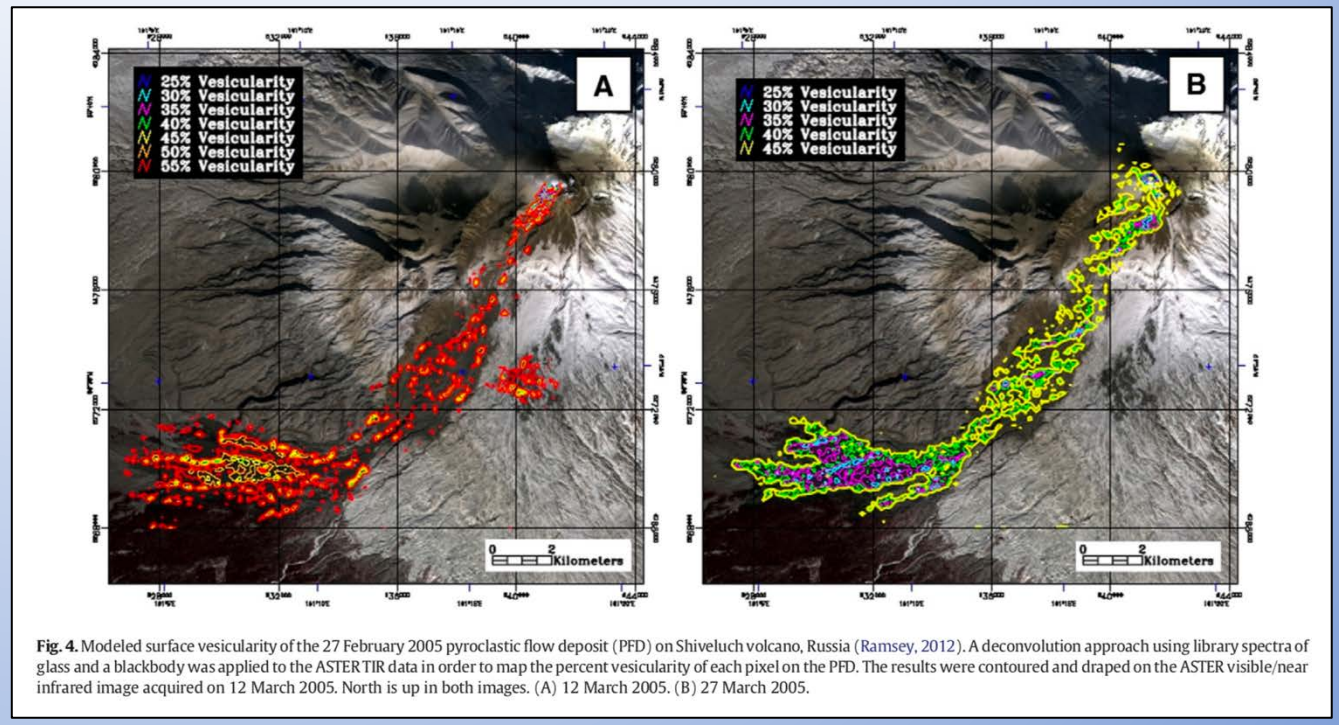


Fig. 4. Modeled surface vesicularity of the 27 February 2005 pyroclastic flow deposit (PFD) on Shiveluch volcano, Russia (Ramsey, 2012). A deconvolution approach using library spectra of glass and a blackbody was applied to the ASTER TIR data in order to map the percent vesicularity of each pixel on the PFD. The results were contoured and draped on the ASTER visible/near infrared image acquired on 12 March 2005. North is up in both images. (A) 12 March 2005. (B) 27 March 2005.

Shiveluch (Russia), vesicularity of pyroclastic flow deposits with ASTER, Ramsey 2012


QUESTIONS?