Volcano Sensor Web 2.0

Volcano Monitoring Using Commercial Satellites and Open Data

James C Mason, Jason Swope, Ashley Gerard Davies, Steve Chien

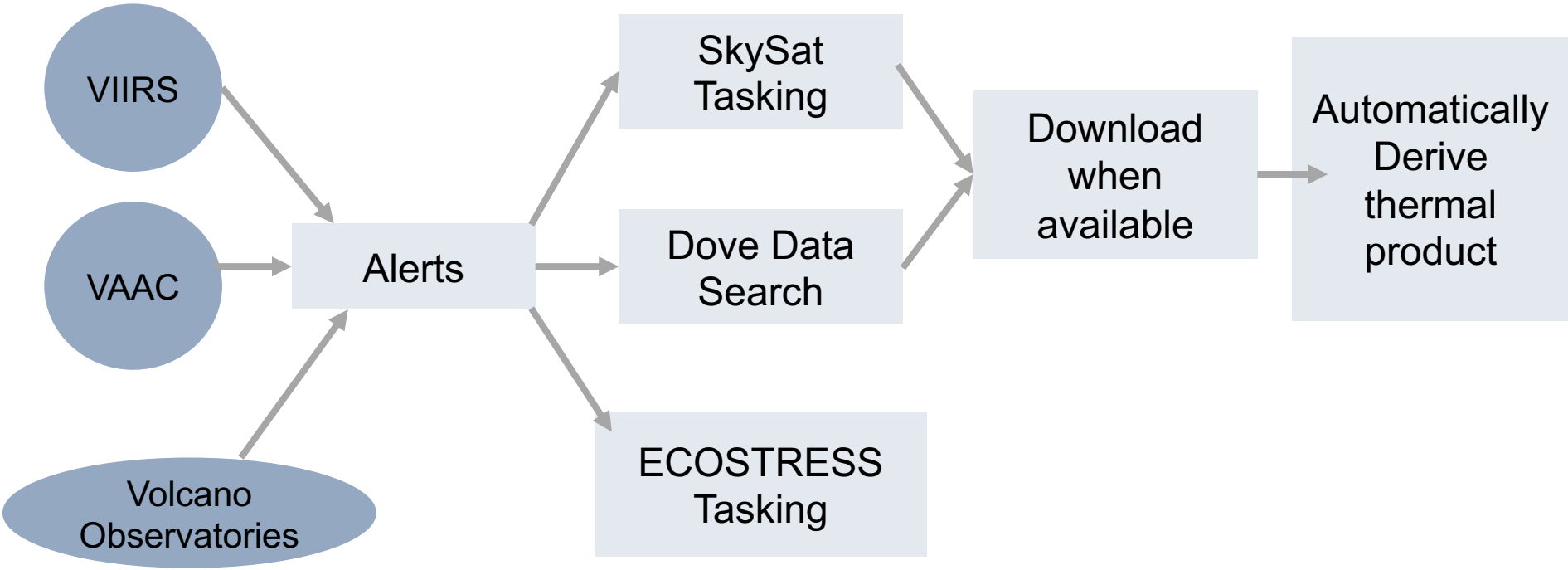
Jet Propulsion Laboratory
California Institute of Technology

Sensorweb Background

- Aggregate data from satellite and in-situ sensors to detect and track phenomena
- Task observations for detected events
- The Volcano Sensorweb (VSW 1.0) operated from 2004 to 2017, led to 9050 observations from EO-1 (~700 observations/year)

- VSW 2.0 extends to commercial constellations
- VSW 2.0 expands the alert generation
- Created thermal classifiers for Planet data

VSW 2.0: Overview Diagram



Number of Alerts by Source

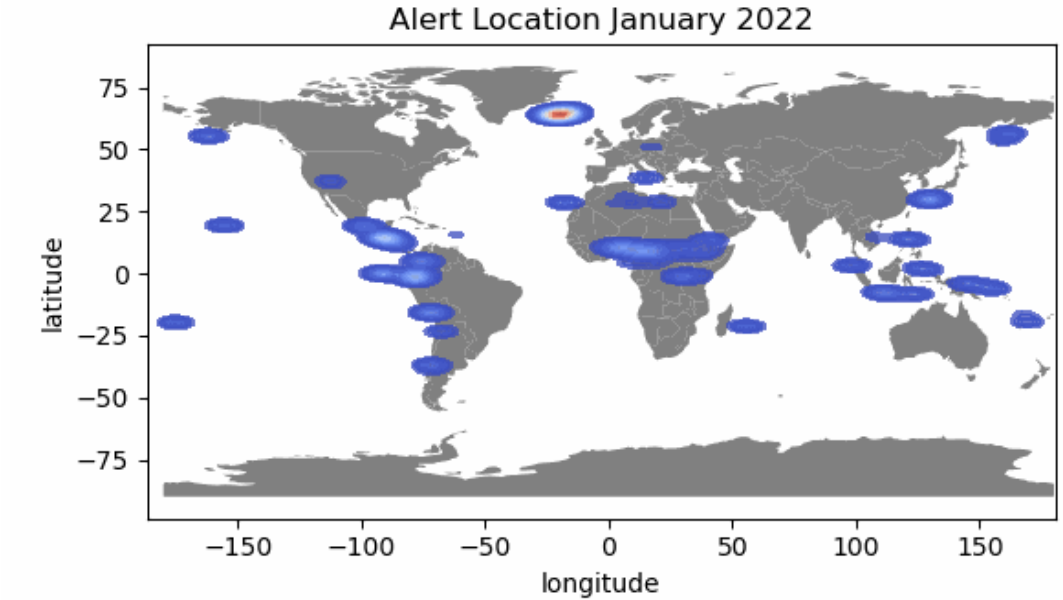
Jan 5, 2022 – May 15, 2023

Source	Count
VIIRS Active Fire	253,555
Volcanological Survey of Indonesia (PVMBG)*	215,344
Iceland Met Office	100,642
Instituto Geofísico, Ecuador (IGEPN)	50,229
VAAC Washington	16,667
VAAC Buenos Aires	11,123

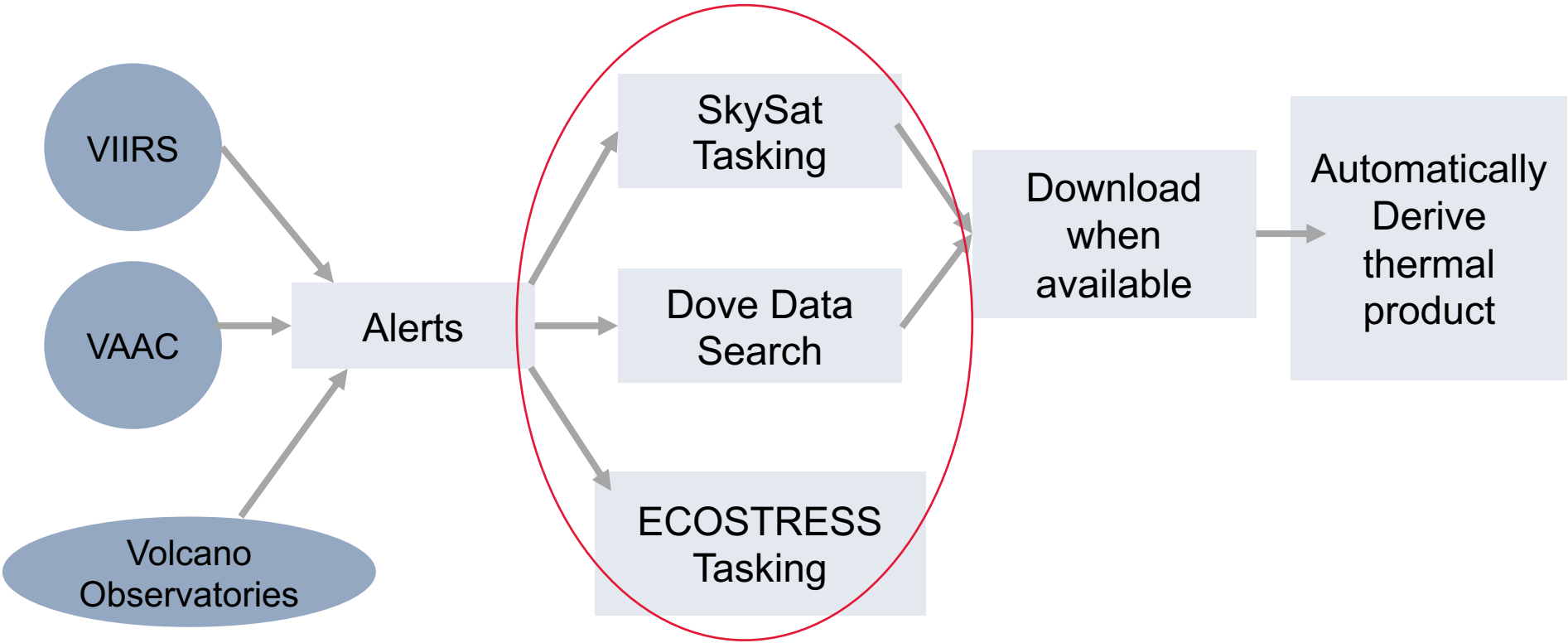
Source	Count
USGS Earthquake	3602
National Geology and Mining Service, Chile (SERNAGEOMIN)	3183
VAAC Tokyo	1654
MODVOLC	891
VAAC Montreal	252
Total	657,142

* - PVMBG creates many alerts because they classify many volcanoes in a low-level alert category, and we create a new alert every time we pull data from a source. This makes sources that report a color status give a higher alert count compared to most event-based sources

Medium+High Priority Alert Location over time



VSW 2.0: Tasking stage



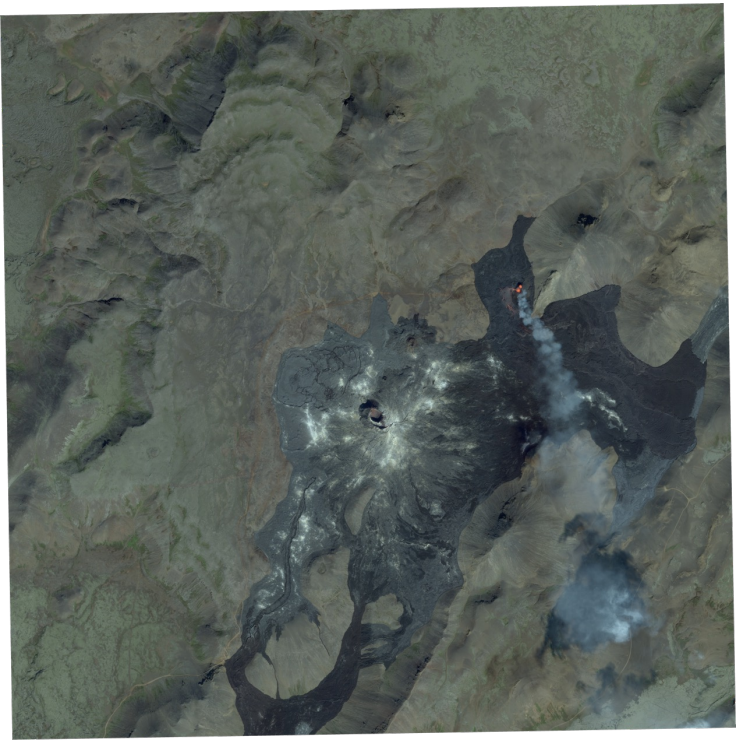
Planet constellation info

- SkySat
  - 21 targetable satellites
  - 4 band instrument (0.45-0.9 microns)
  - 0.5m/pixel resolution
  - SkySat data available to VSW 2.0 as part of a JPL-Planet collaboration
- SuperDove
  - 200+ satellites. Covers the earth’s surface daily
  - 8 band instrument (0.43-0.9 microns)
  - 3m/pixel resolution
  - Data is free to NASA projects after 30 days through CSDA

Tasking

- SkySat:
  - Task the highest priority observation approximately once per week
  - 92 requests between Jan 2022 and June 2023
  - 82 of these requests resulted in at least one captured scene
- ECOSTRESS
  - Add alerts as low-priority requests when scheduling
  - Scheduled 6665 volcanic scenes from Jan-Oct 2022
  - Due to the nature of ECOSTRESS operations, it is unclear how many captures and downlinks occurred
- Dove:
  - Search for coincidental observations after 30 days
  - VSW has found >600,000 coincidental Dove scenes

SkySat – Fagradalsfjall – 15 August 2022

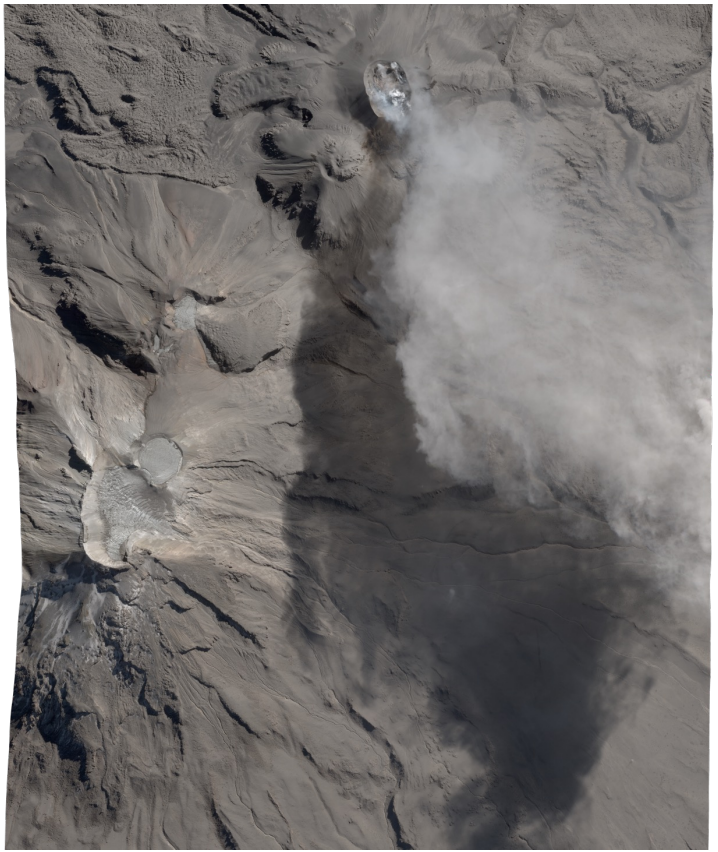


Alert created for Reykjanes on 4th August 2022 from IMO.

SkySat Tasking request to Planet on August 4th.

Planet executed 8 SkySat observations over the next week and a half before meeting quality requirements (clouds)

SkySat – Sabancaya – 11 June 2023

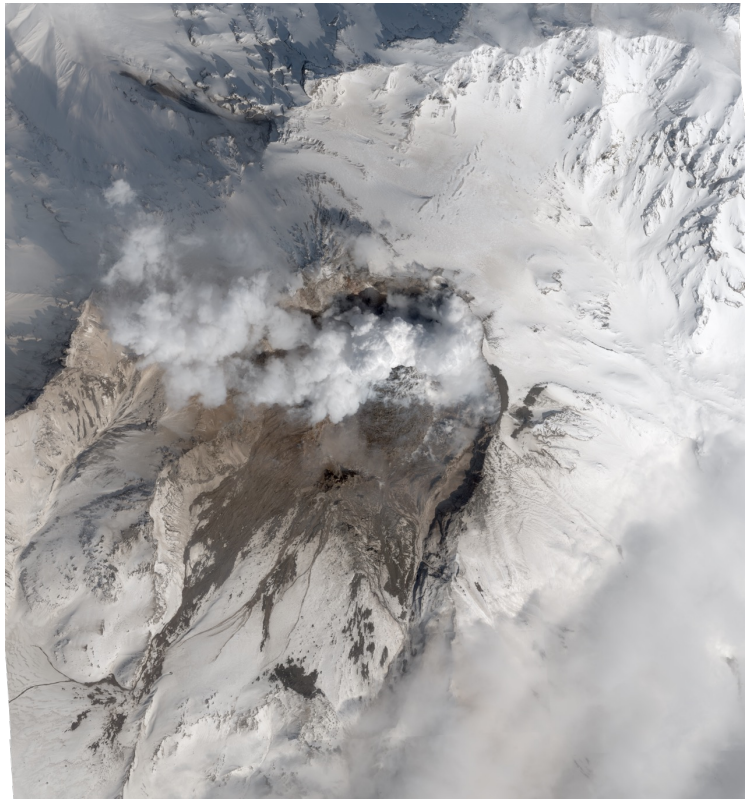


Alert created for Sabancaya on 10th August 2023 from VAAC Buenos Aires.

SkySat Tasking request to Planet on June 10.

SkySat observed on June 11

SkySat – Sheveluch – 27 April 2023



Alert created for Sheveluch on April 20, 2023.

SkySat Tasking request to Planet on April 20.

SkySat made 8 observations until meeting their quality standards on April 29th.

This was one of the invalid observations.

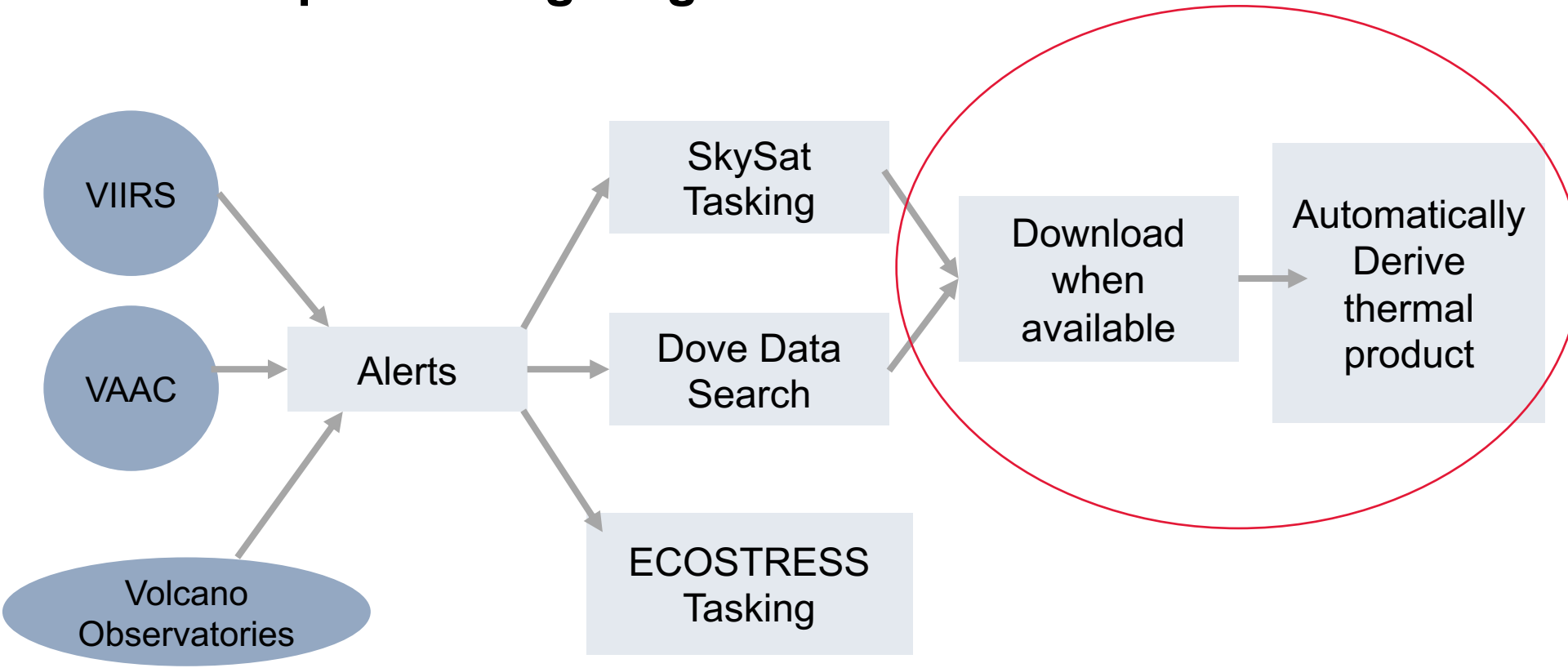
SkySat – Yasur – 20 June 2023

Alert created for Yasur on 17th June 2023 from VIIRS.

SkySat Tasking request to Planet on June 17.

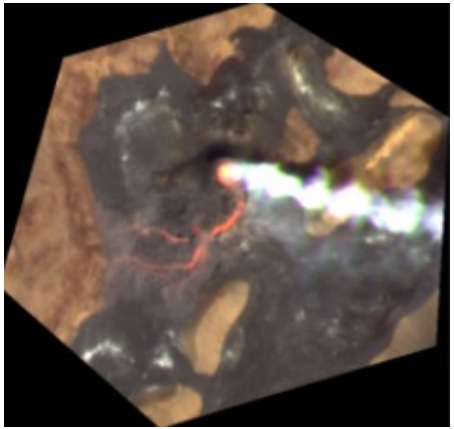
There have been 3 captures, none meeting quality standards

VSW 2.0: processing stage

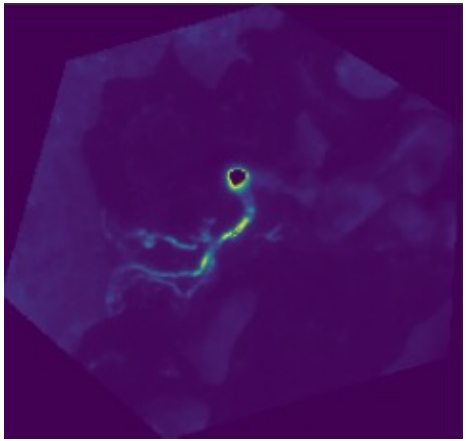


Thermal Classifiers for SkySat, SuperDove

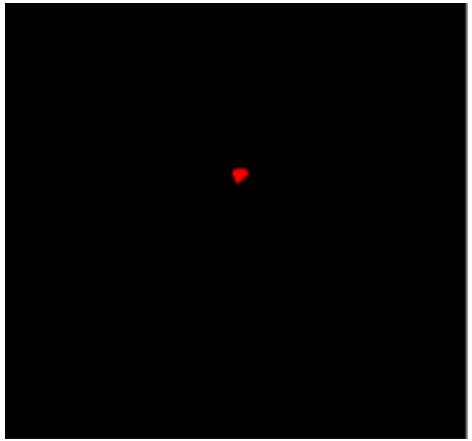
Example product from expert derived classifier for Superdove



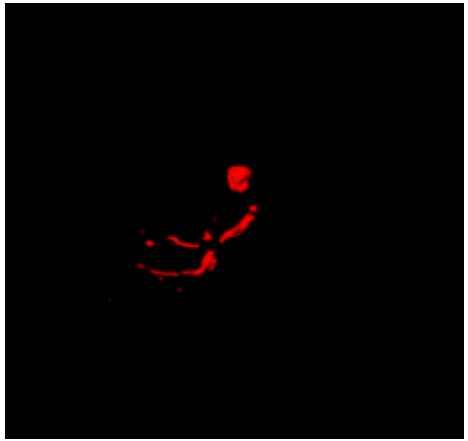
RGB Composite



Band 8 (865nm) with cloud mask applied



Saturated values



Hot and Extreme Pixels

Fagradsalsfjall, June 26, 2021. Data Courtesy Planet Labs

Takeaway

- VSW 2.0 has generated >250,000 alerts from Jan 2022 to June 2023
- VSW 2.0 has acquired:
  - >82 SkySat scenes
  - >600,000 coincidental Dove scenes
  - Scheduled >6,665 ECOSTRESS Scenes
- VSW 2.0 has no operations staff.
- Once configured by the science team, VSW 2.0 operates with no human input and minimal oversight
- We can autonomously monitor volcanoes at low cost

References

[1] S. Chien, J. Boerkoel, J. Mason, D. Wang, A. Davies, J. Mueting, V. Vittaldev, V. Shah, and I. Zuleta, “Leveraging space and ground assets in a sensorweb for scientific monitoring: Early results and opportunities for the future,” in IGARSS. IEEE, 2020, pp. 3833–3836.

[2] S. Chien, A. Davies, J. Doubleday, et al., “Automated volcano monitoring using multiple space and ground sensors,” Journal of Aerospace Information Systems, vol. 17, no. 4, pp. 214–228, 2020.

[3] Planet Labs, “https://www.planet.com/,” Accessed Jan 04, 2023.

[4] “VIIRS Active Fire product,” NRT VIIRS 375 m Active Fire product VNP14IMGT distributed from NASA FIRMS. Available on-line https://earthdata.nasa.gov/firms. doi:10.5067/FIRMS/VIIRS/VNP14IMGT NRT.002.

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[6] Joshua B Fisher, Brian Lee, Adam J Purdy, et al., “Ecostress: Nasa’s next generation mission to measure evapotranspiration from the international space station,” Water Resources Research, vol. 56, no. 4, pp. e2019WR026058, 2020.

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[8] Michael S Ramsey, “Synergistic use of satellite thermal detection and science: a decadal perspective using aster,” Geological Society, London, Special Publications, vol. 426, no. 1, pp. 115–136, 2016.

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Jet Propulsion Laboratory
California Institute of Technology

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