



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

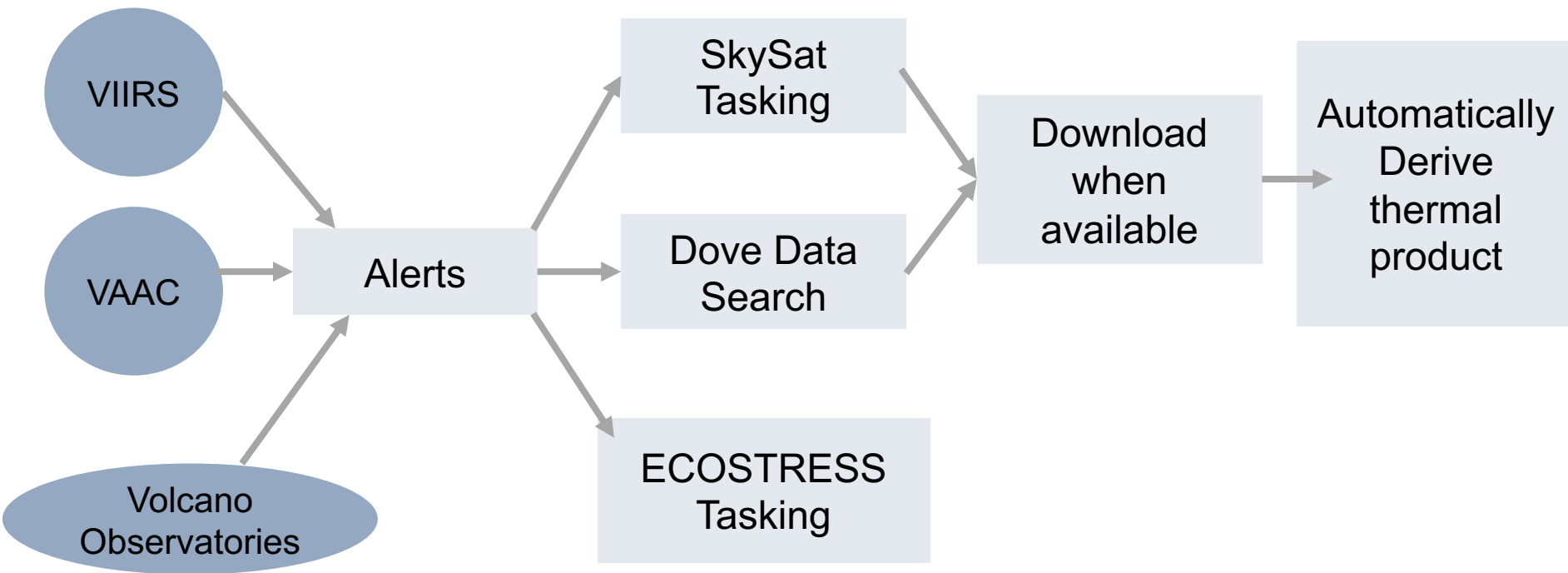
This document has been reviewed and determined not to contain  
export controlled technical data.

© 2023 California Institute of Technology. Government sponsorship  
acknowledged.

# 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

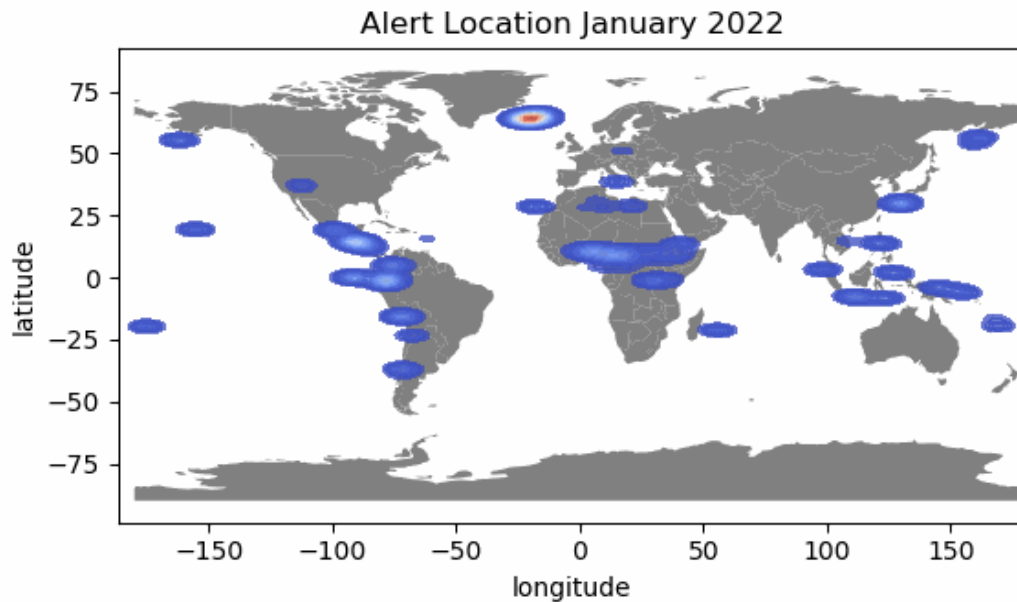
Jan 5, 2022 – May 15, 2023

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

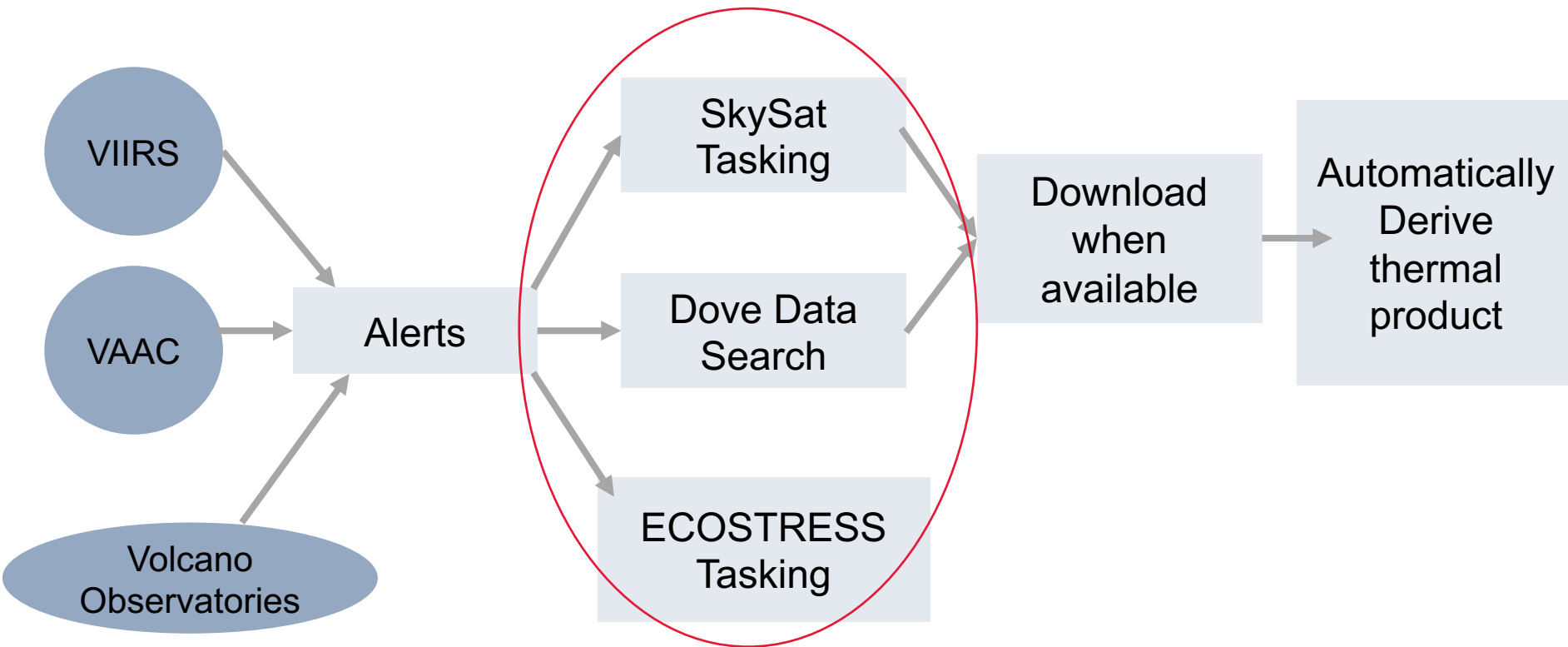
Source	Count
USGS Earthquake	3602
National Geology and Mining Service, Chile (SERNAGEOMIN)	3183
VAAC Tokyo	1654
MODVOLC	891
VAAC Montreal	252
Total	657,142

\* - 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

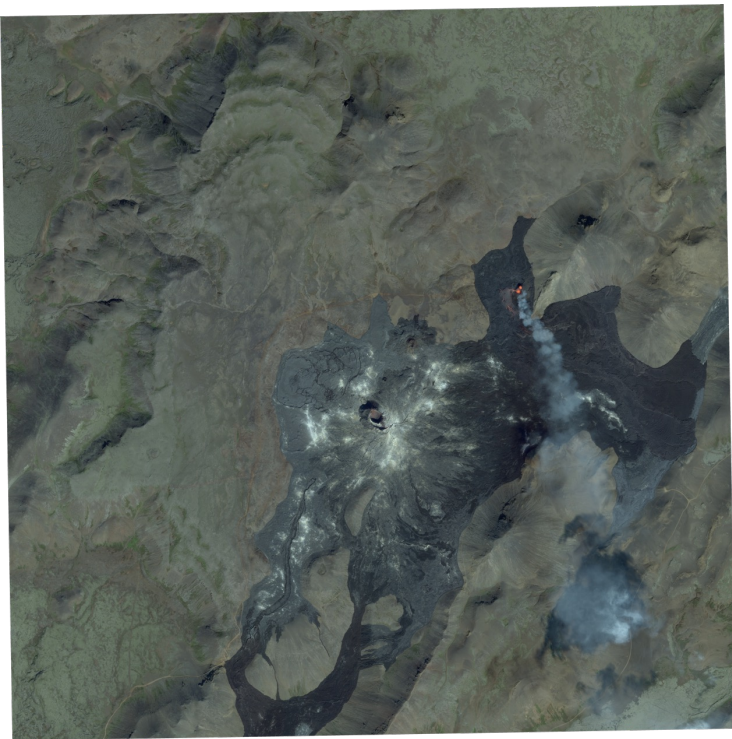


# Tasking

- 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

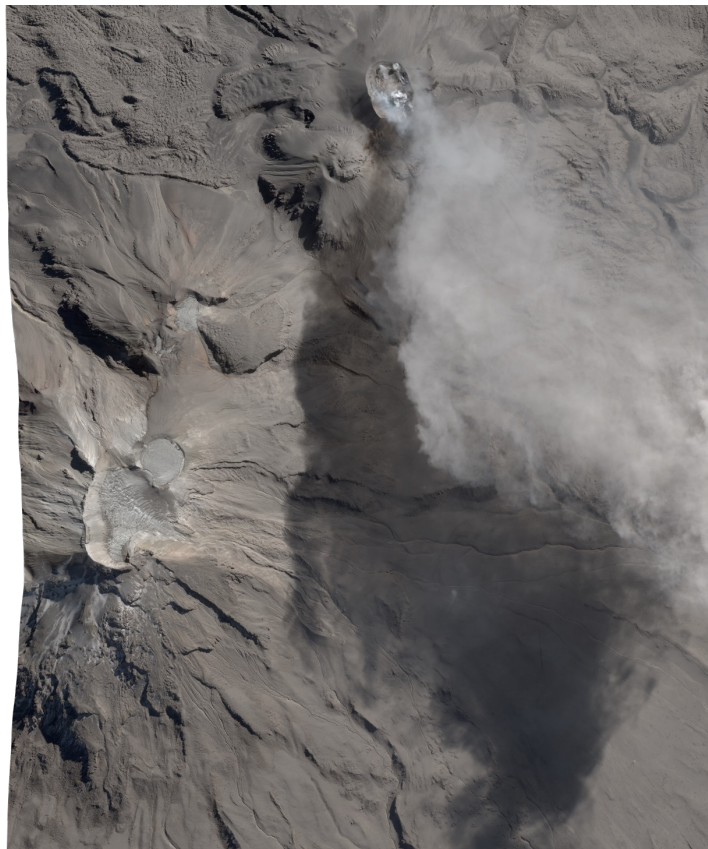


Alert created for Reykjanes on 4<sup>th</sup> August 2022 from IMO.

SkySat Tasking request to Planet on August 4<sup>th</sup>.

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

# SkySat – Sabancaya – 11 June 2023

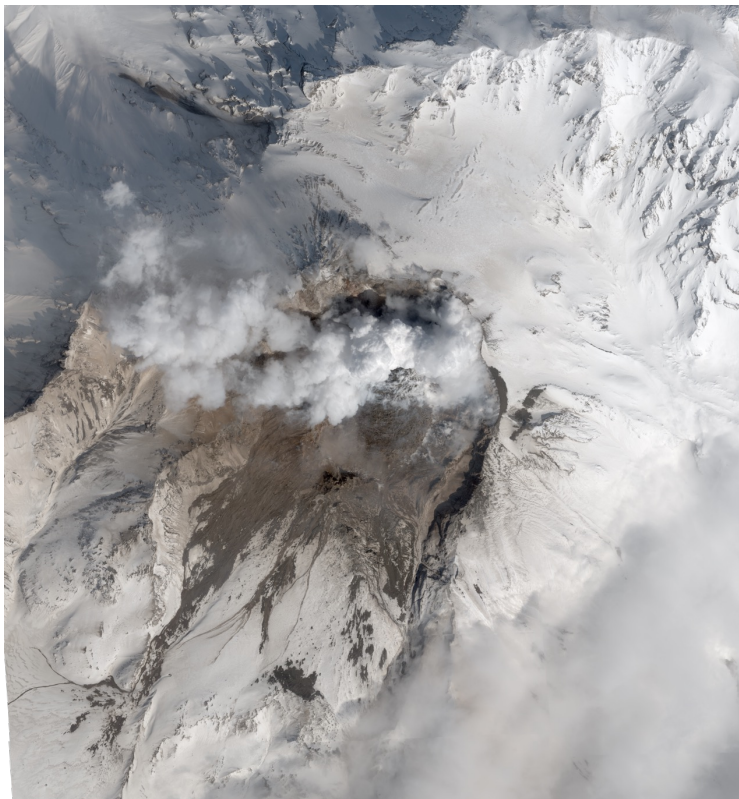


Alert created for Sabancaya on 10<sup>th</sup> August 2023 from VAAC Buenos Aires.

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 29<sup>th</sup>.

This was one of the invalid observations.



# SkySat – Yasur – 20 June 2023

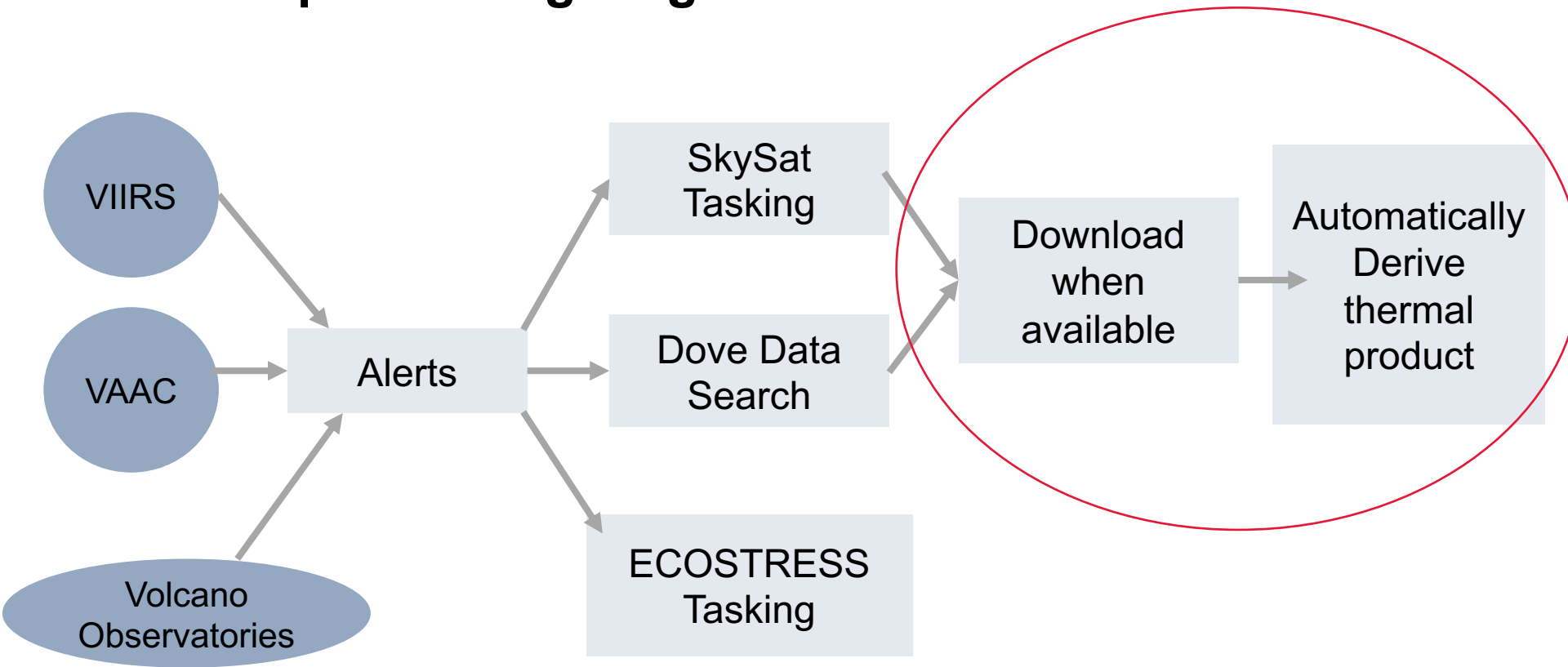


Alert created for Yasur on 17<sup>th</sup> June 2023 from VIIRS.

SkySat Tasking request to Planet on June 17.

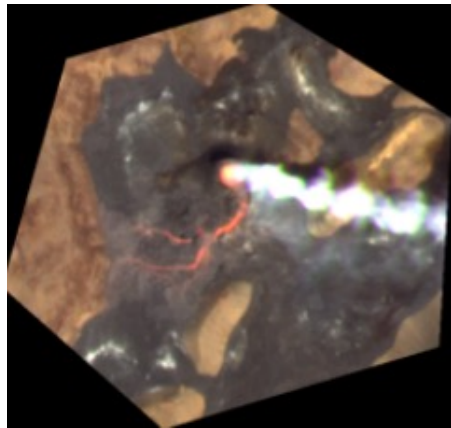
There have been 3 captures, none meeting quality standards

# VSW 2.0: processing stage

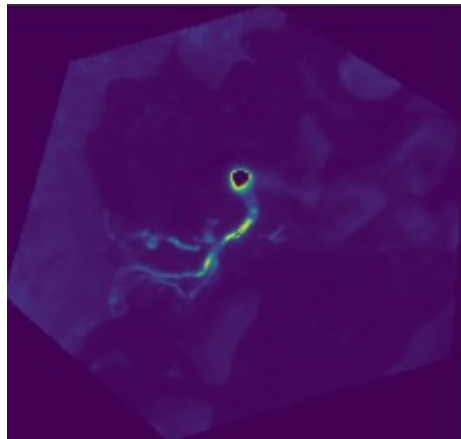


# Thermal Classifiers for SkySat, SuperDove

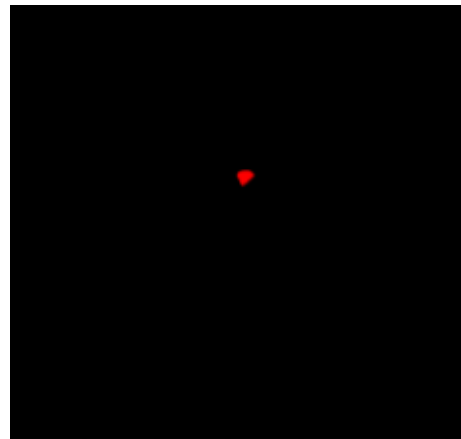
Example product from expert derived classifier for Superdove



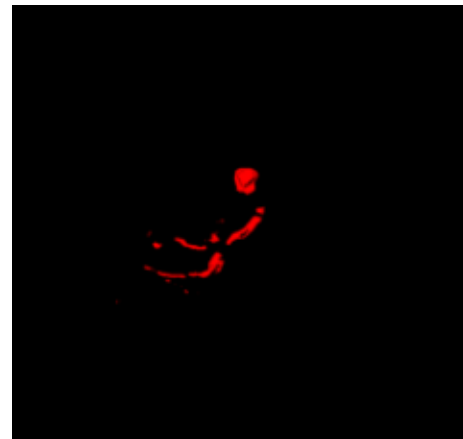
RGB  
Composite



Band 8  
(865nm) with  
cloud mask  
applied



Saturated  
values



Hot and  
Extreme  
Pixels

Fagradalsfjall, 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. Muetling, 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 VNP14IMGD distributed from NASA FIRMS. Available on-line <https://earthdata.nasa.gov/firms>. doi:10.5067/FIRMS/VIIRS/VNP14IMGD NRT.002.
- [5] PVMBG, “MAGMA Indonesia,” <https://magma.vsi.esdm.go.id/>.
- [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.
- [7] R. Wright, L. P Flynn, H. Garbeil, A. JL Harris, and E. Pilger, “Modvolc: near-real-time thermal monitoring of global volcanism,” *Journal of Volcanology and Geothermal Research*, vol. 135, no. 1-2, pp. 29–49, 2004.
- [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.
- [9] Sebastien Valade, Andreas Ley, Francesco Mas-simetti, et al., “Towards global volcano monitoring using multisensor sentinel missions and artificial intelligence: The mounts monitoring system,” *Remote Sensing*, vol. 11, no. 13, pp. 1528, 2019.
- [10] S. Chien, D. McLaren, J. Doubleday, D. Tran, V. Tanpipat, and R. Chitradon, “Using taskable remote sensing in a sensor web for thailand flood monitoring,” *Journal of Aerospace Information Systems (JAIS)*, vol. 16, no. 3, pp. 107–119, 2019.





**Jet Propulsion Laboratory**  
California Institute of Technology

---

[jpl.nasa.gov](https://jpl.nasa.gov)