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The NASA-JPL Volcano Sensor Web (VSW): The Next Iteration

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1. The Volcano Sensor Web (VSW)

Space and ground sensing, and leveraging the "internet of things", are increasingly enabling dramatic new measurements of a wide range of Earth Science and Applied Earth Science phenomena. Increasingly, new private sector space sensors monitor volcanism, flooding, wildfires, weather, and many other processes. We are further developing the VSW using these newly available assets and imaging capabilities. Of particular importance are volcanoes, which can unexpectedly disrupt large areas quickly (for example, Eyjafjallajökull in 2010, [1]).

2. Some history – VSW 1.0

The VSW successfully demonstrated a fully autonomous system linking volcanic activity detection to spacecraft operations, data acquisition and processing, which in turn triggered further spacecraft data acquisition. From 2003 to 2017, the VSW orbital asset was NASA's *Earth Observing 1* Hyperion imager [1-3]. The VSW demonstrated fully autonomous spacecraft operation and data acquisition, reduction and analysis [1-3]. Over 8000 observations of volcanoes were obtained at 30 m/pixel spatial resolution and high spectral resolution from 0.4 to 2.4 μm [1-3]. Spectral classifiers identified and quantified hot pixels in Hyperion data [1, 2].

3. VSW 2.0 – Planet Doves and SkySats

The new iteration of the VSW is the result of collaboration between the VSW and Planet Labs. This collaboration utilizes Planet's constellations of Dove CubeSats and SkySat SmallSats, restoring global coverage capability to the VSW. Activity notifications from such sources as MODVOLC [4] and others (see **Fig. 1**, "Triggers", and [1-3]) generate requests to Planet for SkySat observations. Already, VSW triggers have resulted in over 50 SkySat observations.

4. Information flow and data processing

Figure 1 shows the desired configuration of the VSW, with the goal of restoring the autonomous capabilities of VSW 1.0. Notifications of volcanic activity generate requests for spacecraft observations. On data acquisition, downlink, and acquisition by the VSW at JPL, the data will be processed to identify thermally anomalous pixels and to quantify and map the temperature and area distribution and thermal emission. Robust detection of high-temperature sources, once summarised, are sent to end-users; such detections generate requests for more observations.

5. Data processing

SkySat and Dove imagers (from 455 nm to ~900 nm) are particularly sensitive to the thermal emission from the hottest areas of an ongoing volcanic eruption, such as active vents, lava fountains, overturning lava lakes, and open channel flows. We are currently developing new data classifiers, using a mixture of band ratios and thresholding (**Figures 2** and **3**), to isolate these hot pixels from the cooler surrounding areas. Such detections enable deeper analysis of the data and volcanological processes taking place [e.g., 1], and can also trigger new observation requests**.**

6. Future Plans

We are now moving towards automated tasking of the Planet SkySat constellation, driven by triggers generated by the sensor web described above.

We are refining thermal anomaly detection algorithms for incorporation into the VSW for both Dove and SkySat observations.

We are developing classifiers for ECOSTRESS data (the VSW is currently tasking ECOSTRESS to obtain volcano observations).

We aim to expand the VSW by incorporating more triggers and working closely with volcano observatories and volcanologists around the world.

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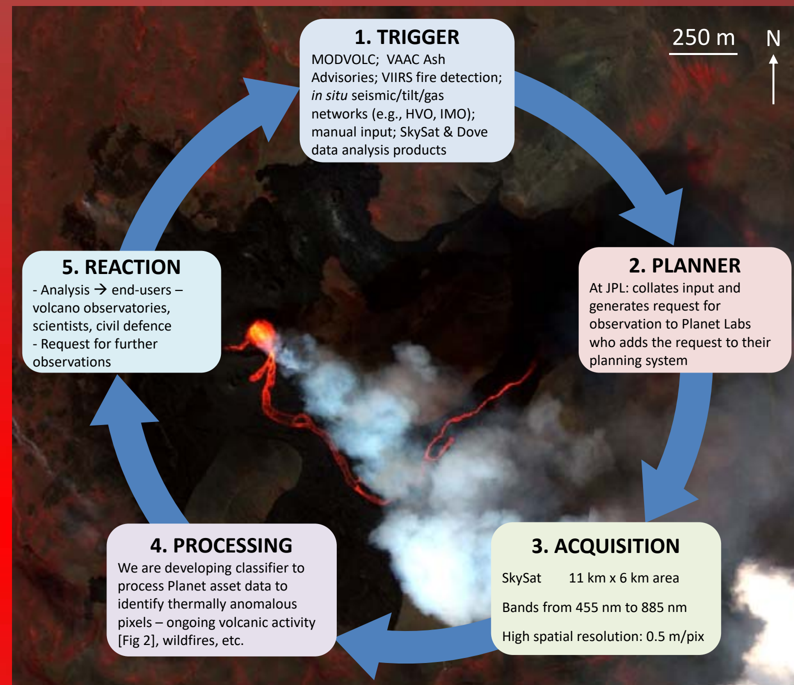

Figure 1. Volcano Sensor Web work flow. Background image: Fagradalsfjall, Iceland, 2021-05-11 SkySat observation. Data are 0.5 m/pixel and are obtained at 8 wavelengths (visible to short infrared).

Figure 2. Ratio of Band 3/Band 4 SkySat data to enhance the hottest pixels in the scene.

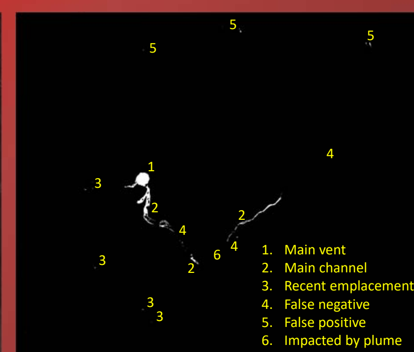

Figure 3. Mixture of band ratio and thresholding to isolate the hot pixels. We are refining the algorithm to reduce false positives and false negatives.

References: [1] Davies, A.G. et al. 2013. *JGR-Solid Earth*, 118, 1–21, doi:10.1002/jgrb.50141. [2] Davies A.G. et al., 2016. The NASA Volcano Sensor Web, in "*Detecting, Modelling and Responding to Effusive Eruptions*", eds. Harris, A. et al., GSL, London. [3] Chien, S. et al. 2020. *JAIS*, 17(1), doi:10.2514/1.I010798. [4] Wright, R. et al. (2002) *RSE*, 82, 135– 155.

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