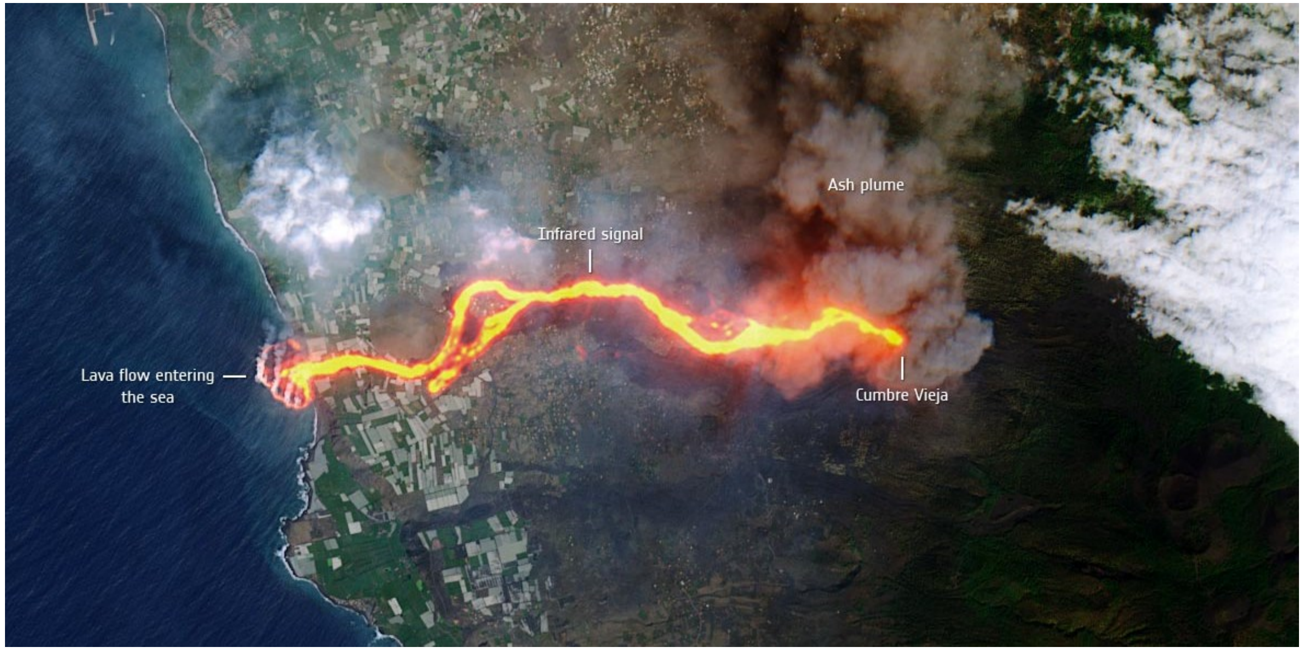
Volcano hazard monitoring using remote sensing techniques during the Cumbre Vieja volcano 2021 eruptive crisis



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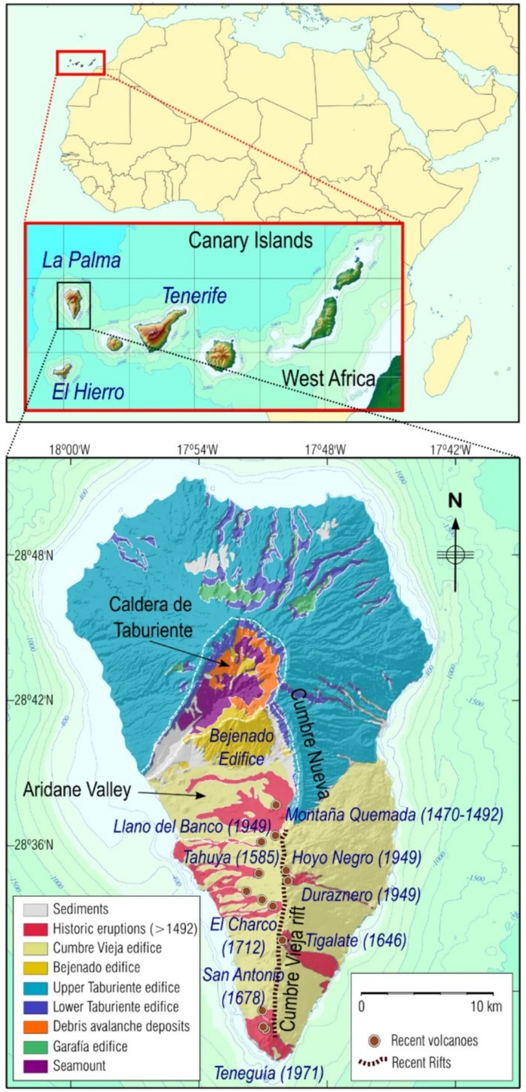
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

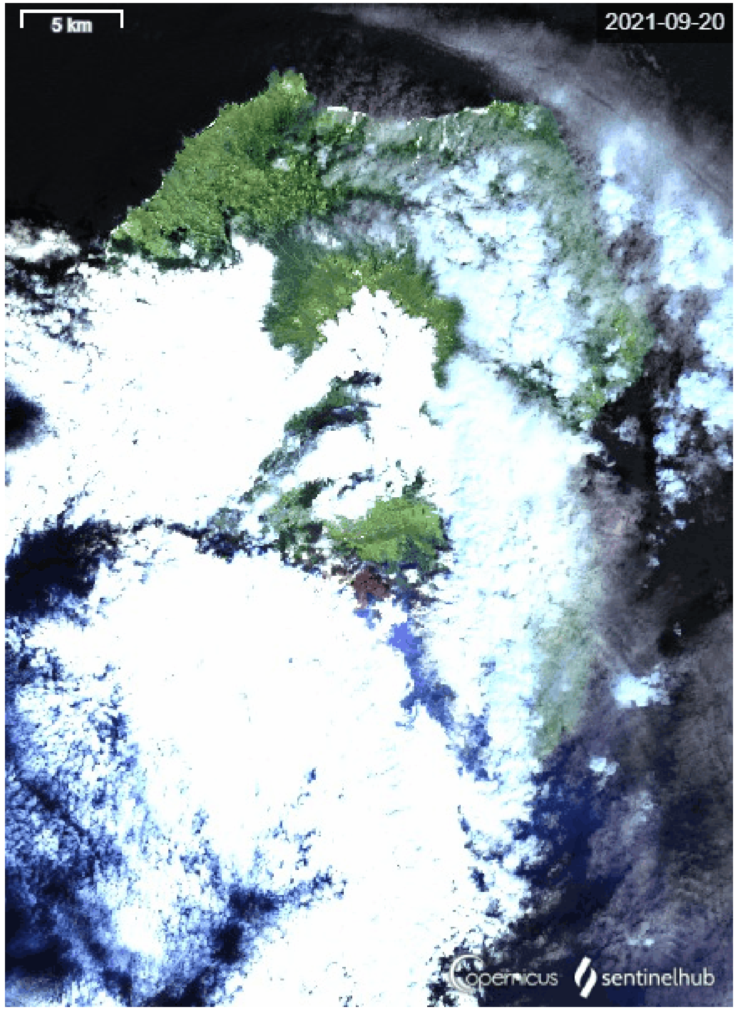
OSSERVATORIO ETNEO
SEZIONE DI CATANIA

The 2021 Cumbre Vieja Eruption

On 19 September 2021, after about 50 years of quiescence, a new eruption started at Cumbre Vieja volcano (Canarias, Spain). The onset was preceded by a series of seismic swarms, the last one of which occurred on 11 September 2021.
A system of eruptive fissures opened and multiple vents produced lava fountains, sustained ash columns, and lava flows that travelled over 5 km W to the sea, damaging hundreds of properties along their path. The eruption forced the evacuation of over 7,000 people and destroyed nearly 3,000 buildings, ending on 13 December, after 85 days.

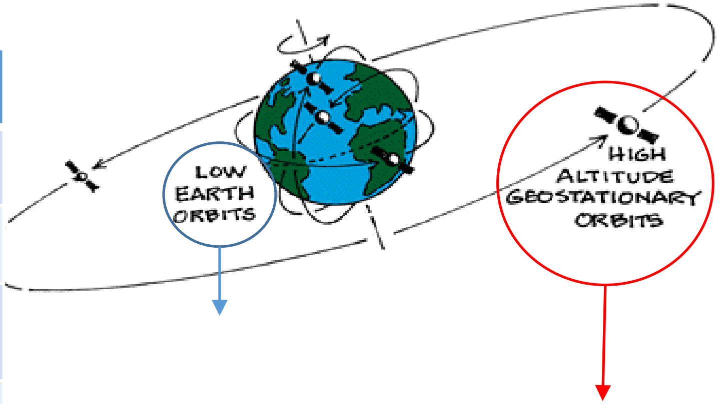


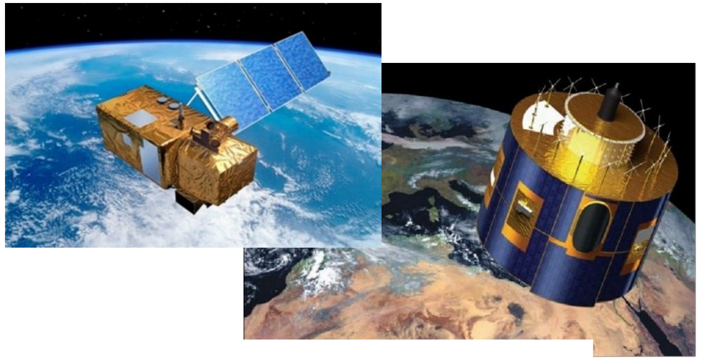
Fernandez et al 2021



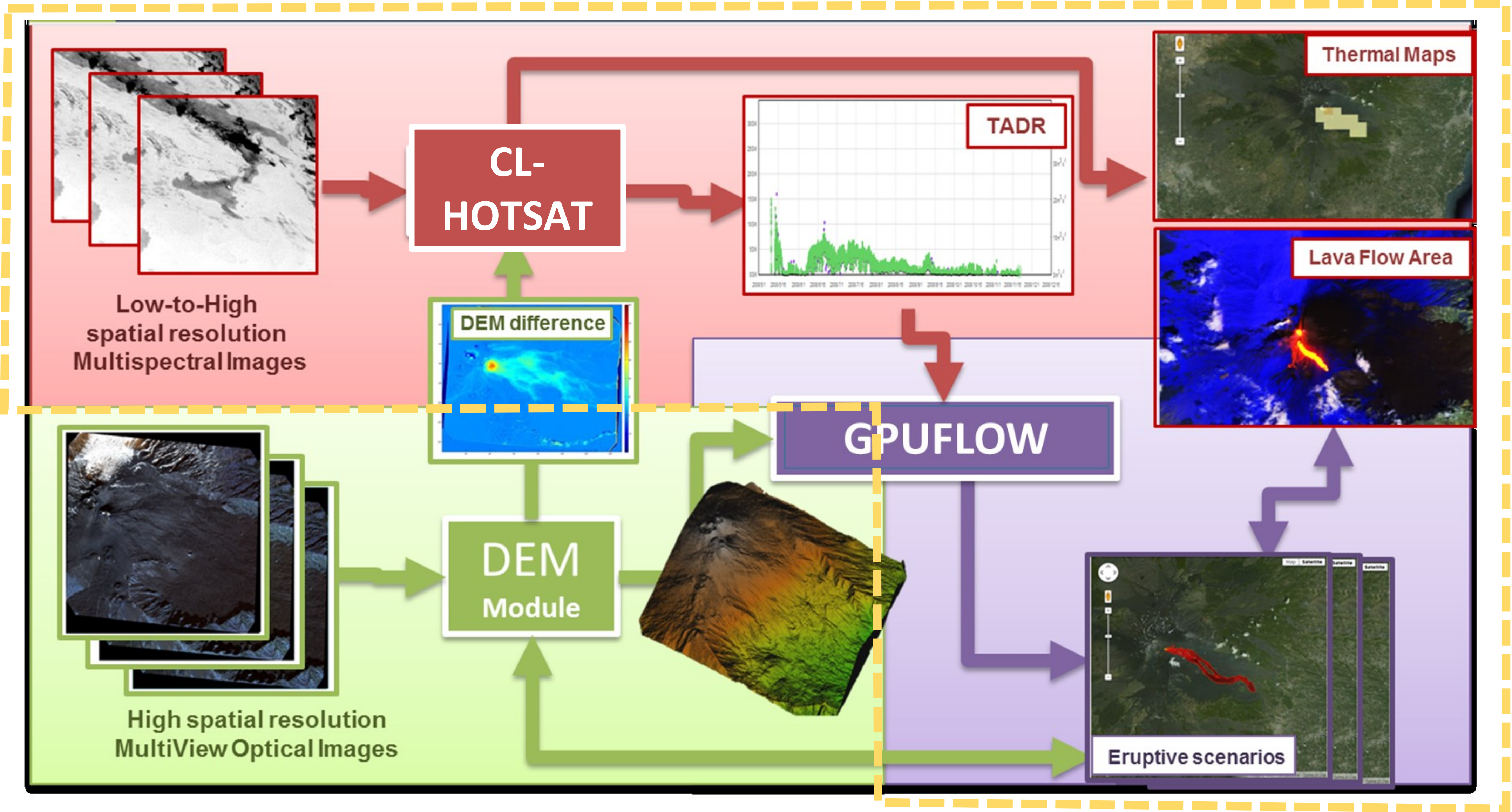
Satellites and sensors for Volcano Monitoring

Satellite Sensor	Spatial Resolution	Revisit Time	Derived Product
MSG-SEVIRI	3 km	15 minutes	Radiant Heat Flux, TADR
EOS-MODIS	1 km	12 h	Radiant Heat Flux, TADR
Sentinel 3-SLSTR	1 km	12 h	Radiant Heat Flux, TADR
NPP/JPSS-VIIRS	375 - 750 m	12 h	Radiant Heat Flux, TADR
Landsat 8- OLI	15 - 30 m	7-14 days	Lava flow thermal map
Sentinel 2- MSI	10 - 60 m	2-3 days	Lava flow thermal map
EOS-ASTER	15 - 90 m	On demand	DEM, Lava flow area/thickness
Pleiades-1A, -1B	0.5 - 2 m	On demand	DEM, Lava flow area/thickness
Doves-PlanetScope	3.7 m	~1 day	DEM, Lava flow area/thickness
SkySat	0.7 - 1 m	On demand	DEM, Lava flow area/thickness



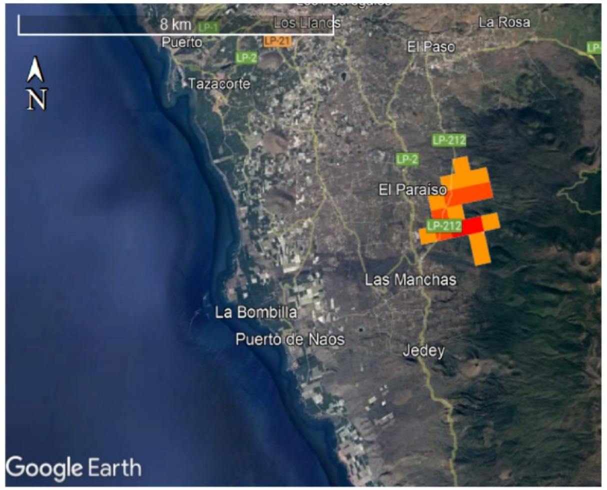


Methodology for Volcano Hazard Monitoring

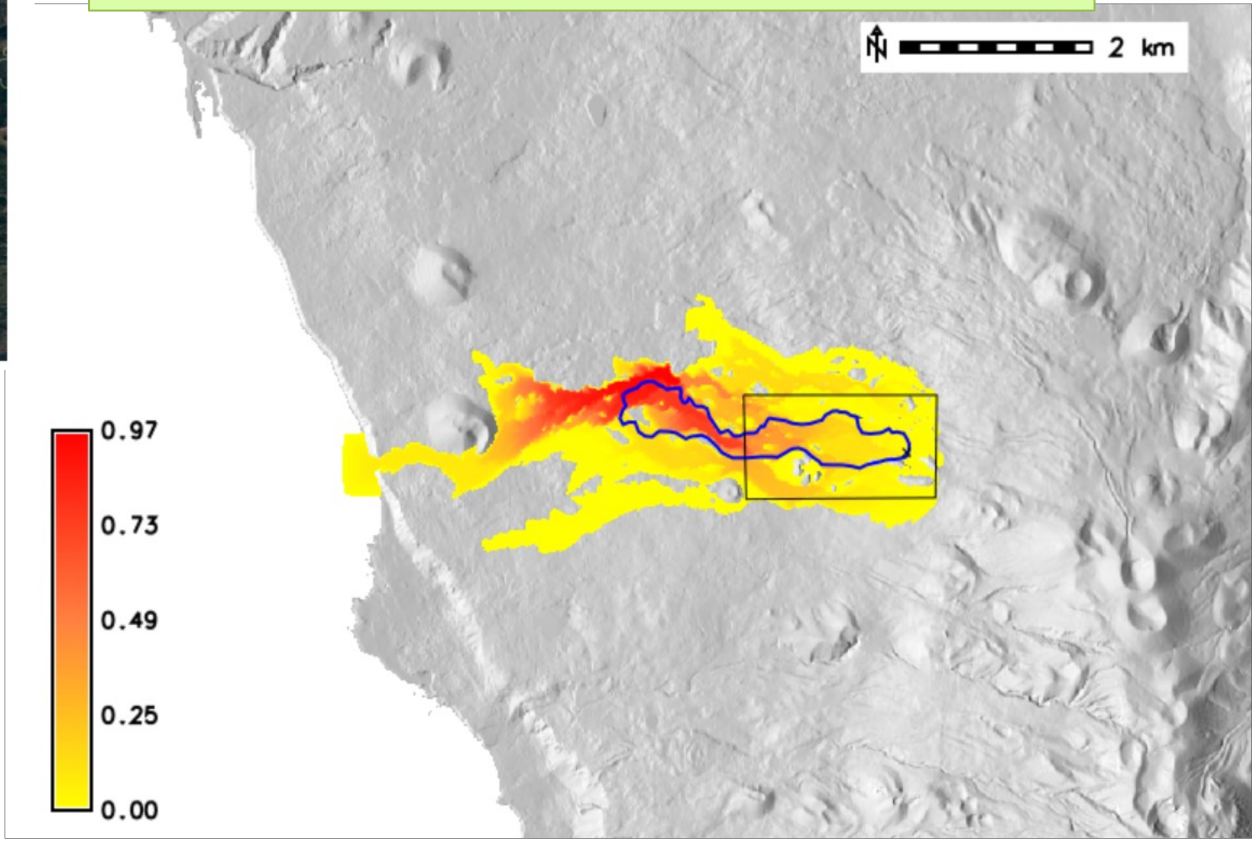


Short term Hazard Map - GPUFLOW

Maps of thermal anomalies derived from the VIIRS band I4 (375m spatial resolution) acquired on 19 September 2021 at 14:26 GMT (left) and on 20 September 2021 at 02:50 GMT (right).

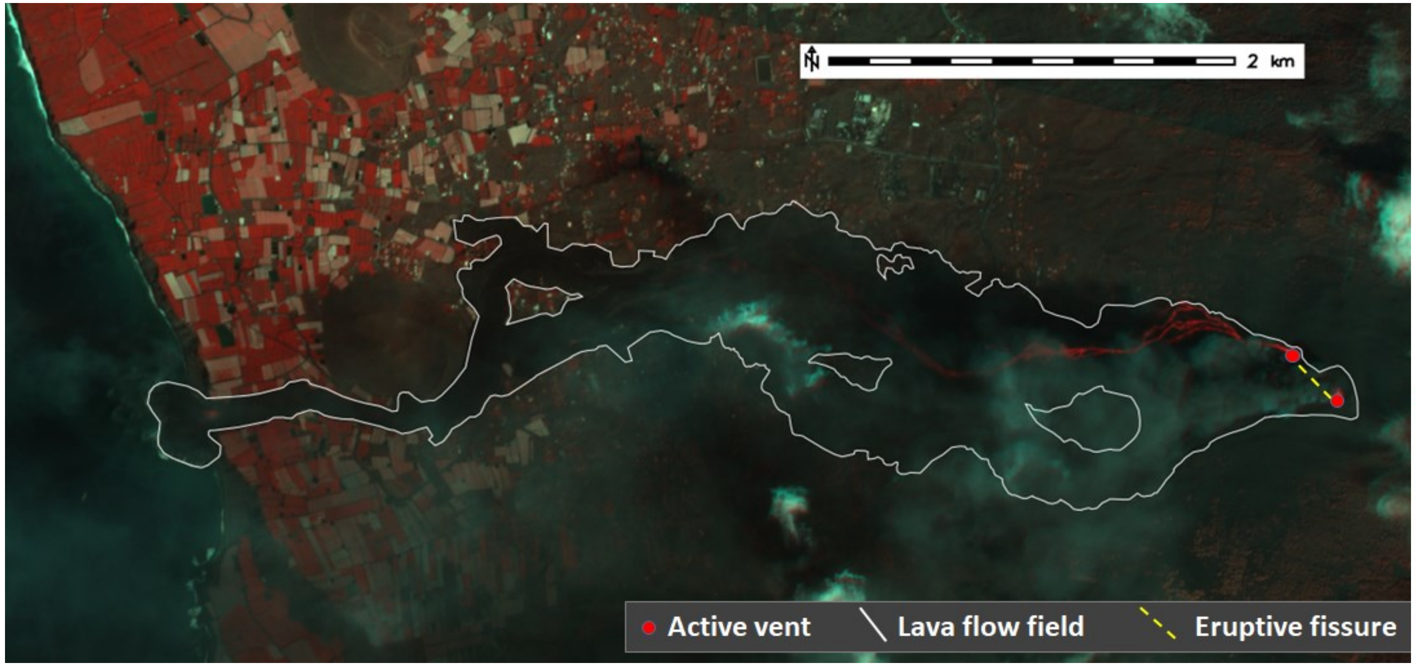


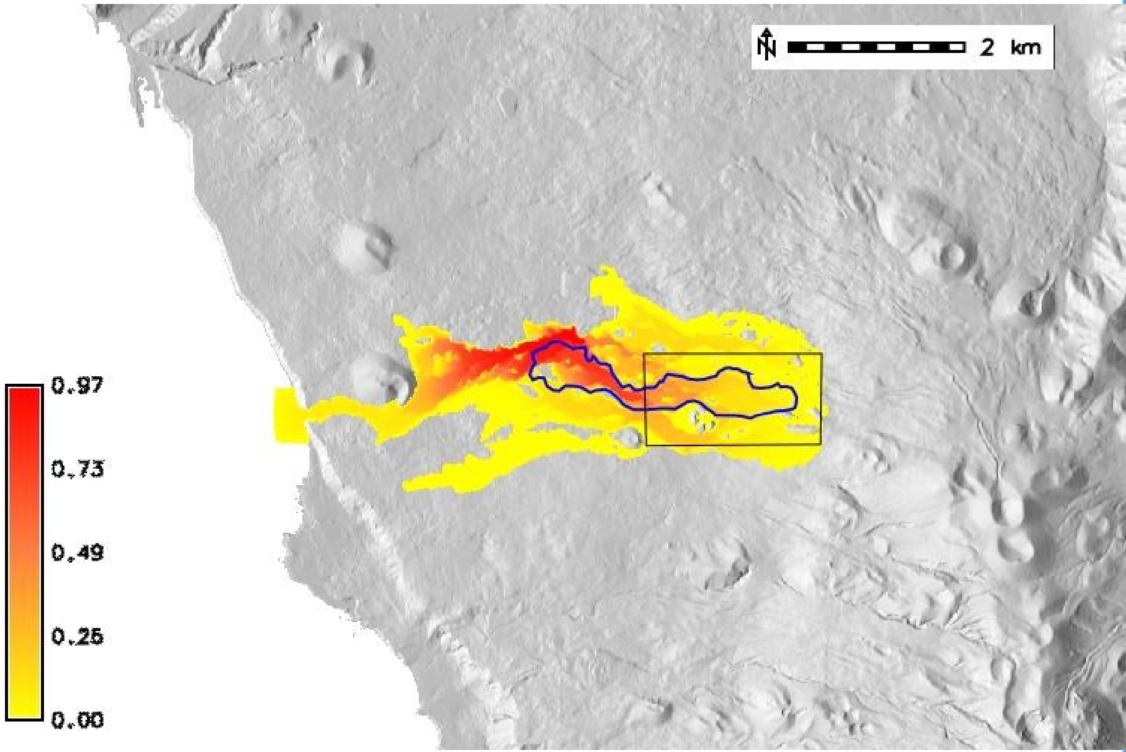
We defined a 2 sqkm grid centered on the most thermally active pixel retrieved from VIIRS with 100 m spacing, where the 231 grid points represent hypothetical eruptive vents. For each grid vent, we executed a GPUFLOW simulation assuming a constant effusion rate of 20 m3/s for three days.



For the physical properties of the lava, we used the typical properties of basaltic rocks: density (2600 kg m-3); specific heat capacity (1150 J kg-1 K-1); emissivity (0.9); solidification temperature (1173 K); extrusion temperature (1360 K).
The lava flow inundation probability was computed considering the overlapping of the final simulated lava flows.

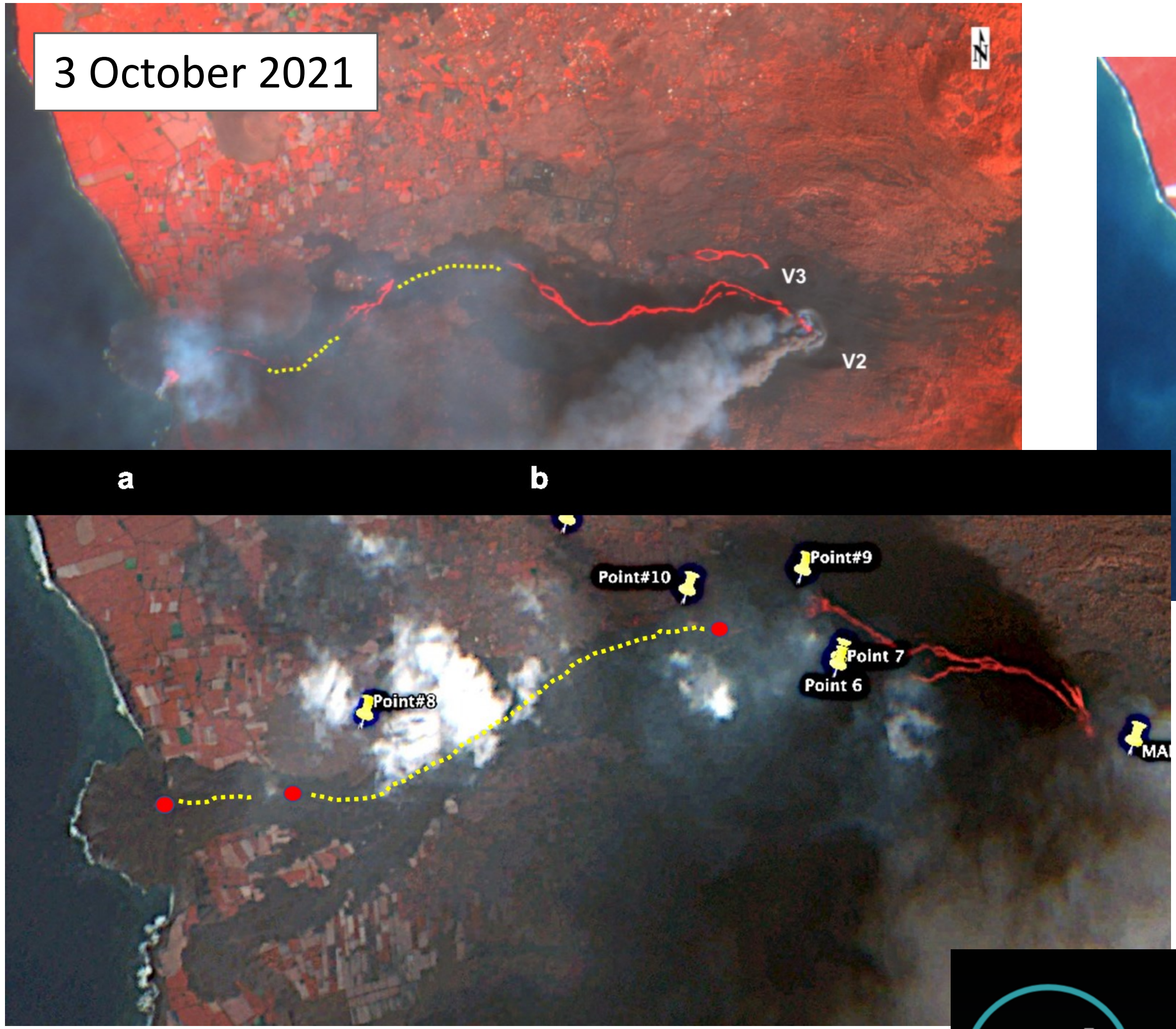
Short term Hazard Map - GPUFLOW

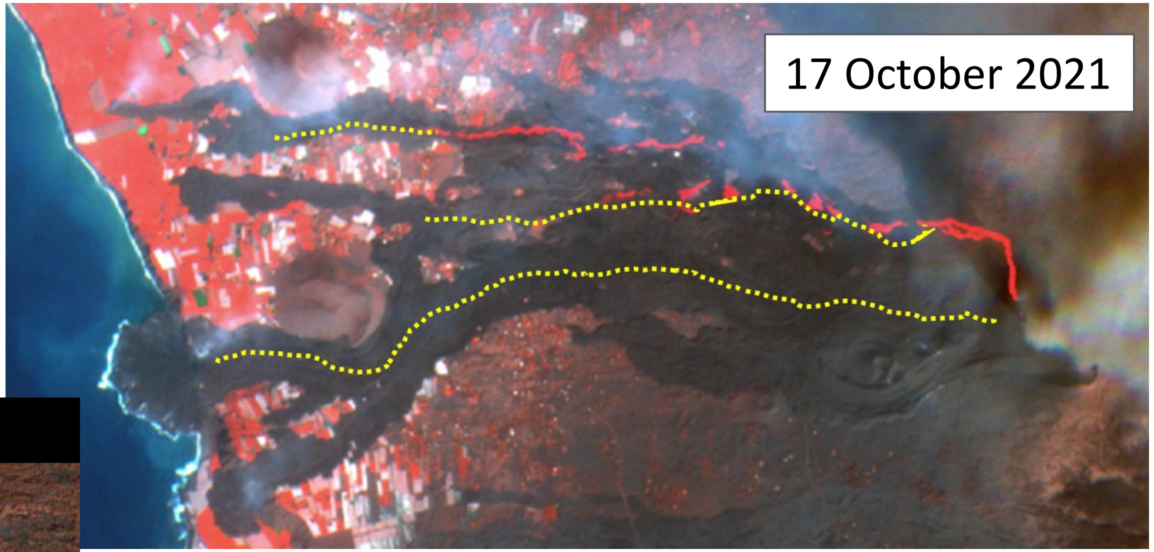


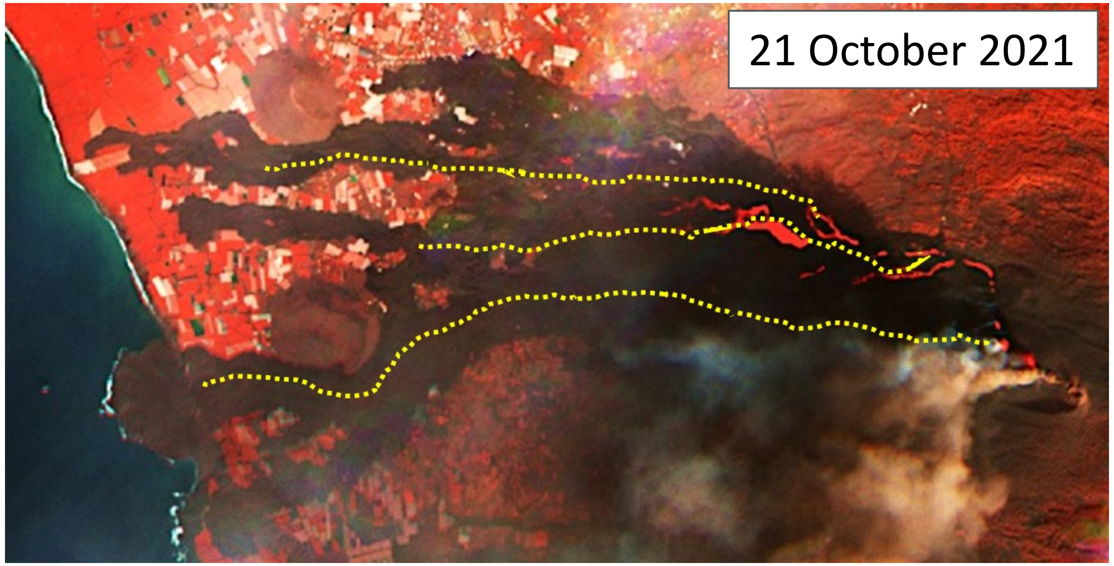


RGB composite (Band 4,2,1) of the Planetscope image acquired on 29 September 2021 at 11:25 GMT. The white contour delineates the lava flow field, the dashed yellow line the eruptive fissure, while red dots are the active vents.

Lava Tubes monitoring from Planetscope imagery







Education and Research (E&R) Program

Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com.

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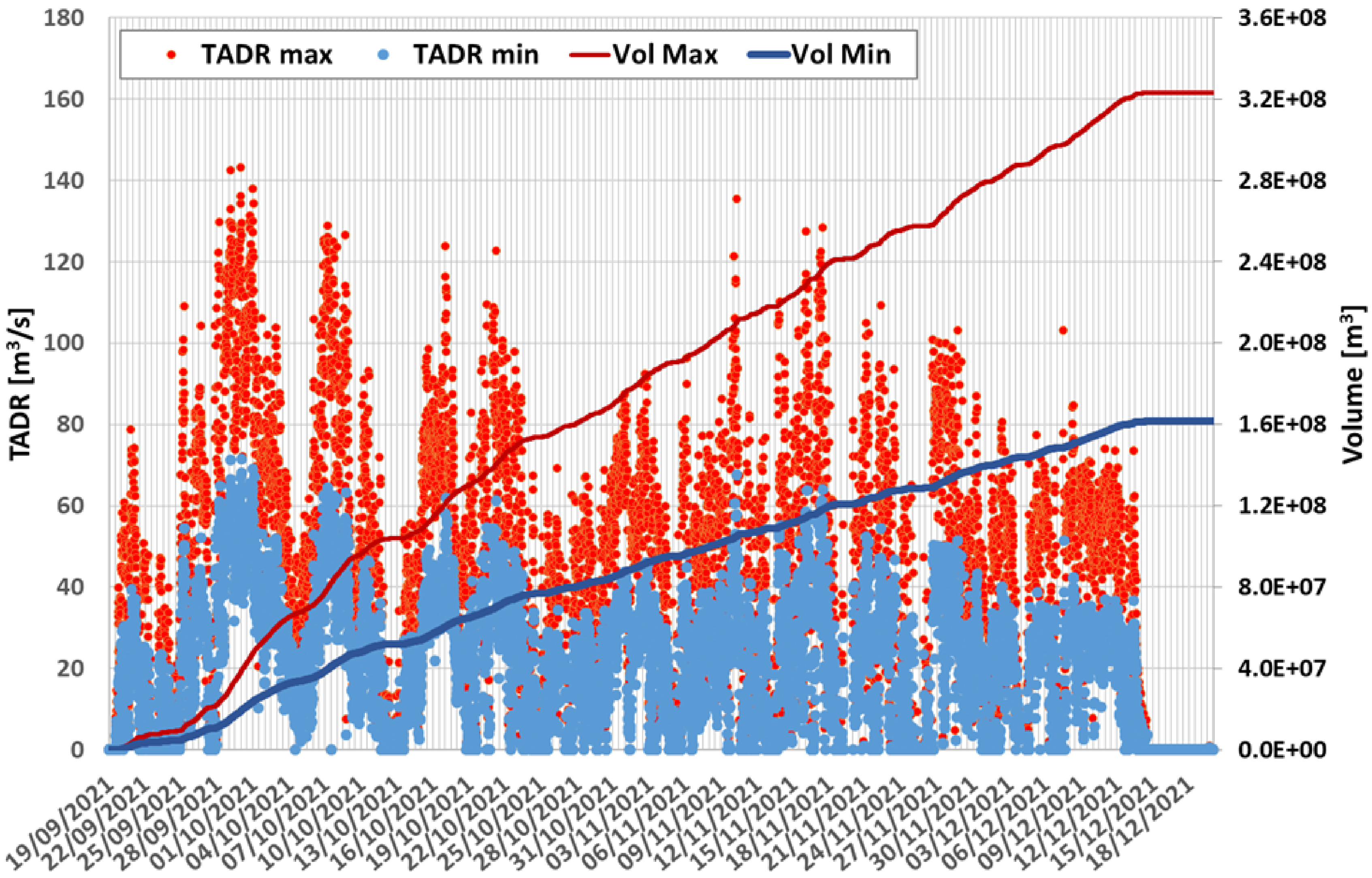
CL- HOTSAT: Time Averaged Discharge Rate from SEVIRI



By integrating the TADR, we obtained a first estimation of the erupted volume of about 242 ± 80 million cubic meters.

This is a preliminary estimate, since the same parameters of the Etnean lavas were used. Moreover underestimations can be due to the lava flow spreading within the sea.

More information on the lava characteristics is required for a more accurate conversion from radiant heat flux to TADR.

Future developments: IR products calibration through tri-stereo images