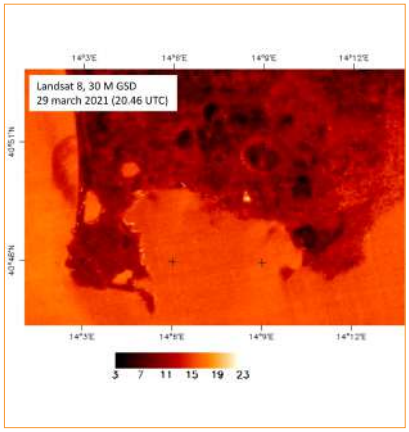
SURFACE TEMPERATURE Observations from SATELLITE

Over the last 25 years, satellite measurements in the thermal infrared have proved well suited to obtain surface temperature maps at regional scale. Satellite thermal images are useful tools to analyze volcanic phenomena and to map the total thermal flux from active lava flows.

AUTOMATED PROCESSING CHAINS FOR SURFACE TEMPERATURE MONITORING ON EARTH'S MOST ACTIVE VOLCANOES AND ENVIRONMENTAL APPLICATIONS

The estimation of land surface temperature (LST) using Thermal InfraRed (TIR) remote sensing data is a well-developed method offering a quick way to estimate reliable parameters of land surface physical processes at different scales with a positive cost–benefit ratio. The use of satellites offers the possibility of acquiring data in difficult or dangerous to access areas. Automated processing chains have been developed to quickly obtain satellite products.



EO data	Band centers (µm)	Spatial Resolution (m)	Resolution time
ASTER (TIR)	8.29; 8.63; 9.07; 10.66; 11.32	90	16 days
Landsat 8 (TIRS)	10.9; 12.0	100	16 days
Sentinel-2 (MSI)	0.86; 1.61; 2.20	20	4-5 days
Sentinel-3 (SLSTR)	3.74; 10.85	1000	12h
EOS-MODIS	3.96; 11.03	1000	12h
MSG-SEVIRI	3.9; 10.8	3000	5-15 minutes
VIIRS	3.74; 11.45	375-750	12h

SPATIAL RESOLUTION AND REVISIT TIME

The use of TIR satellite sensors is a consolidated technique to analyze volcanic activity. Different types of spatial resolution are adopted: low (i.e., Meteosat Second Generation (MSG) and Geostationary Operational Environmental Satellite (GOES) with 3-4 km ground resolution), moderate (i.e., MODIS, Sentinel-3 (SLSTR) with 1 km ground resolution and VIIRS with 375-750 m) and high (Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), TIRS Landsat 8/9 (L8/9) with 100 m ground resolution and Sentinel-2 (MSI) with 20 m for Short Wave InfraRed (SWIR) channels). In the first case, the low spatial resolution of satellite sensors does not allow the detection of thermal anomalies in small areas of the order of a hundred meters, even if the high revisiting time allows near real time monitoring. In the second case, the moderate spatial resolution of sensors provides TIR measurements daily and can be used for quantitative analysis including measurements of surface temperatures, effusion rates, and heat flux, even if smaller thermal anomalies cannot be detected.
In the last case, the high spatial resolution TIR sensors are the most useful for quantitative measurements and analysis even if their low revisiting time (16 days) makes them ineffective for real-time monitoring due to the transient nature of many volcanic processes.

PROCESSING CHAINS FOR LST AND VOLCANIC ERUPTIONS

The processing chains developed at the Centro Osservazioni Spaziali (COS) of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) can help the data user communities to quickly obtain an estimation of surface temperature and, in case of volcanic eruption, the detection of lava flows. Moreover, if an effusive eruption occurs, the total heat flux can be converted into Time Averaged Discharge Rate (TADR), that is an estimation of the effusion rate. By integrating the TADR with respect to time, the emplaced volumes can be quantified.

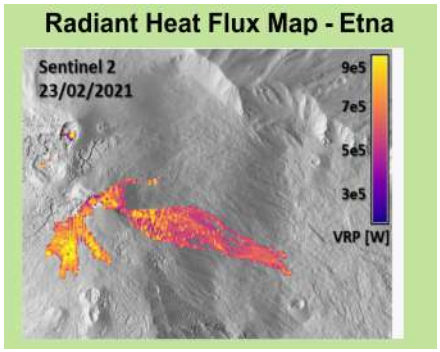
graphic design Laboratorio Grafica e Immagini | INGV

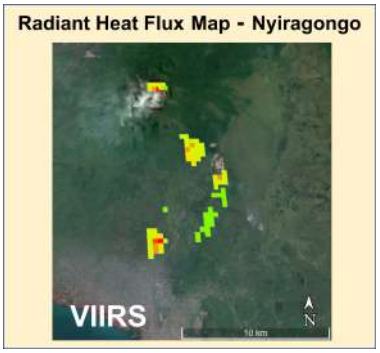
Products

The outputs of processing chains are maps of surface temperature and radiant heat flux at different spatial scales focused on active volcanoes and geothermal areas. Lava flows maps are also produced to follow and analyze the evolution of volcanic events.

RADIANT HEAT FLUX AND LAVA FLOW EVOLUTION

The radiant heat flux can be measured from satellite data with a certain percentage of error (about 30%), while the proportionality constant for the conversion to TADR is case specific and highly variable. The satellite-driven modeling strategy is applied to several volcanoes worldwide for quantifying lava flow hazards in response to effusive eruptions. The accuracy of this strategy, especially in poorly monitored volcanoes, has been limited by: (i) the reliability of the conversion from the radiant heat flux, derived from multi-spectral satellite images, to TADR; (ii) the opportunity for an on-line validation of simulated flow paths against the actual ones. The lava flow evolution can be obtained using Copernicus Sentinel-2 and Landsat 8/9 polar satellites acquiring 20x20 m and 30x30 m, respectively.





PRODUCTS DISSEMINATION

The dissemination tool is the last of three processing steps which combines modules operation, scientific operators validation with data from other technological laboratories (i.e. temperature from thermal cameras, drones measurements) and dissemination of the validated products to the final users. The developed processing chains produce a temporal evolution of the lava flow enabling the extraction of information in the GIS environment from each single piece of data processed. All results are available on an open WebGIS. These processing chains can help the data user communities to quickly obtain an estimation of surface temperature and, in case of volcanic eruption, the detection of lava flow using optical data satellite. The aim is to enable the easy extraction of valuable knowledge from vast quantities of satellite-sensed data now being produced by Europe's Copernicus programme and other Earth observation satellites. In this context, the estimation of surface temperature on active volcanoes around the world is considered.

All the space-related INGV flyers are here!

These chains have been implemented enabling the use of EO missions and the generation of added value products such as surface temperature maps from not skilled users. This solution will enhance the use of satellite data and improve the dissemination of the results saving valuable time (no manual browsing, downloading or processing is needed) and producing time series data that can be speedily extracted from a single co-registered pixel, to highlight gradual trends within a narrow area.