

# Multi Scale Multi Temporal Approach for Volcanic Eruptions monitoring using Optical Satellite data

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CEOS meeting, September 5-6 2018, Napoli

# Summary

- INGV Multi scale and multi temporal optical satellite monitoring of volcanoes
- processing chain for surface temperature analysis within ESA-GEP project
- Active lava flows monitoring on Etna and Kilawea volcanoes
- ESA-VEGAN project products and achievements

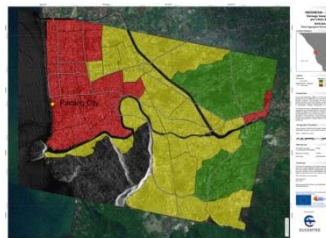
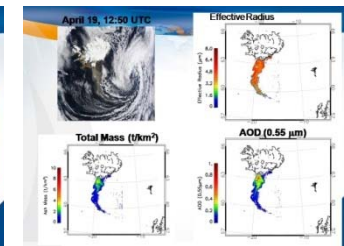
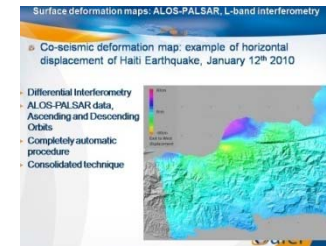
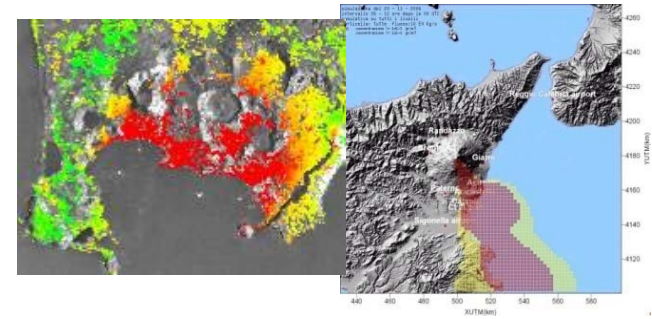
# RISK PHASES

# SERVICES

# PRODUCTS



<p><b>Service/Product</b> <b>Volcano</b></p>
<p>DIFSAR velocity map Thermal mapping Degassing plumes</p>
<p>DIFSAR surface displacement maps Effusion rate Volcanic clouds (ash, so2)</p>
<p>Change detection Maps New lava flows Ash cover New surface morphology</p>





# EMERGENCY CORE SERVICE IMPLEMENTATION

INGV has contributed to COPERNICUS and National Actions focused on the development of integrated system using satellite and ground data

## VOLCANO SERVICES

Initial period  
(2004-2008)

- FP6-PREVIEW
- ASI-SRV

Implementation period and Initial operations  
(2009-2014)

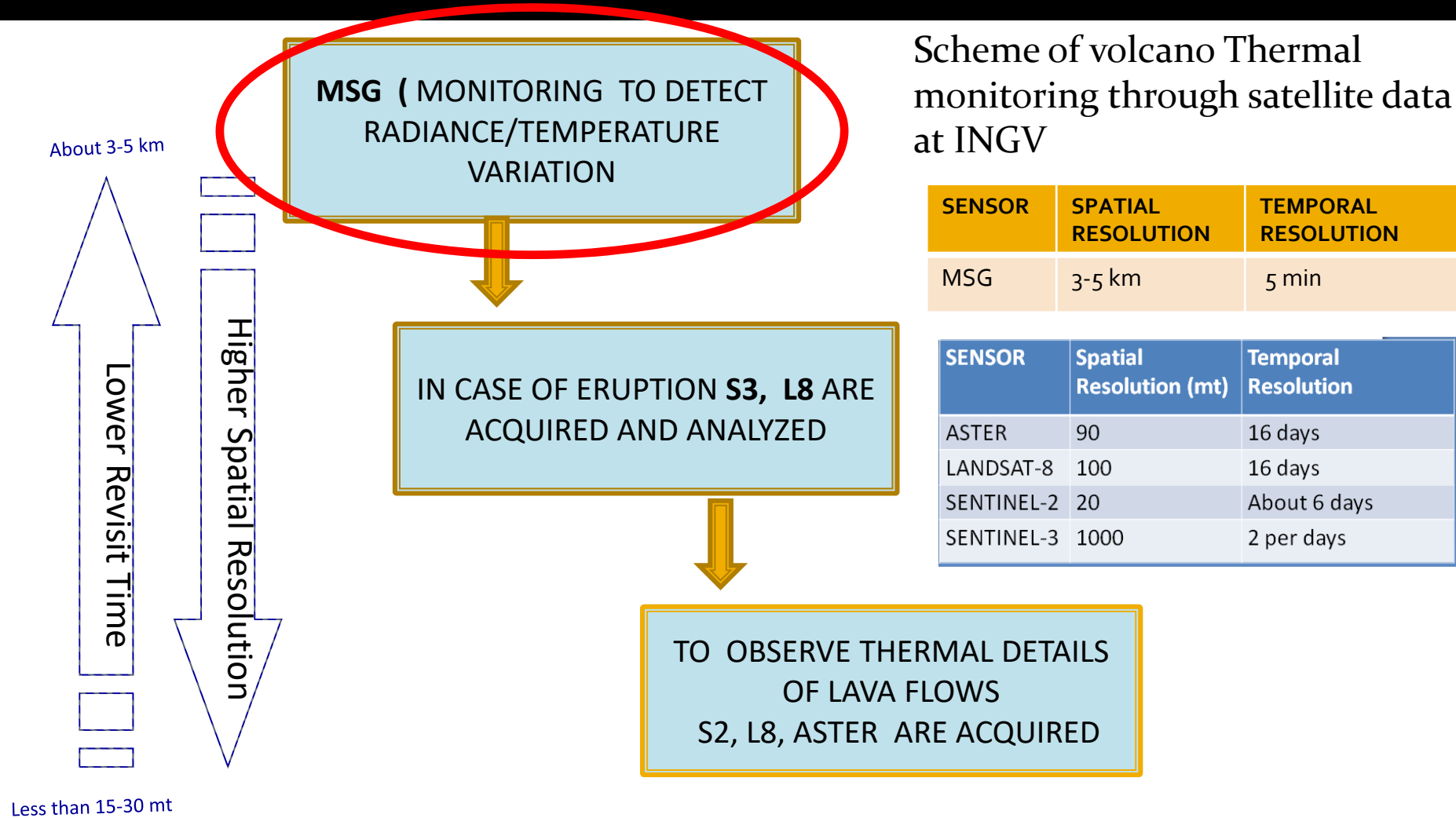
- FP7-SAFER
- ASI-SRV

Implementation of systematic processing chains  
(2015-2018)

- ESA-GEP
- ESA-VEGAN



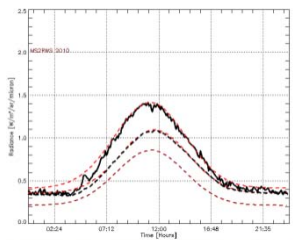
# Multi scale and multi temporal optical satellite monitoring approach



# MS<sub>2</sub>RWS: Rapid Response Web Service



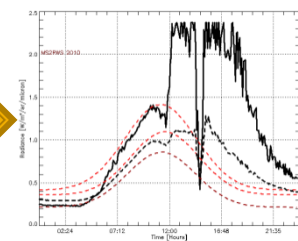
The service is currently active  
On Italian active volcanoes  
It could be activated for other  
volcanoes of the world  
The systems is usefull to get rapid  
Information on the starting of an  
eruption and



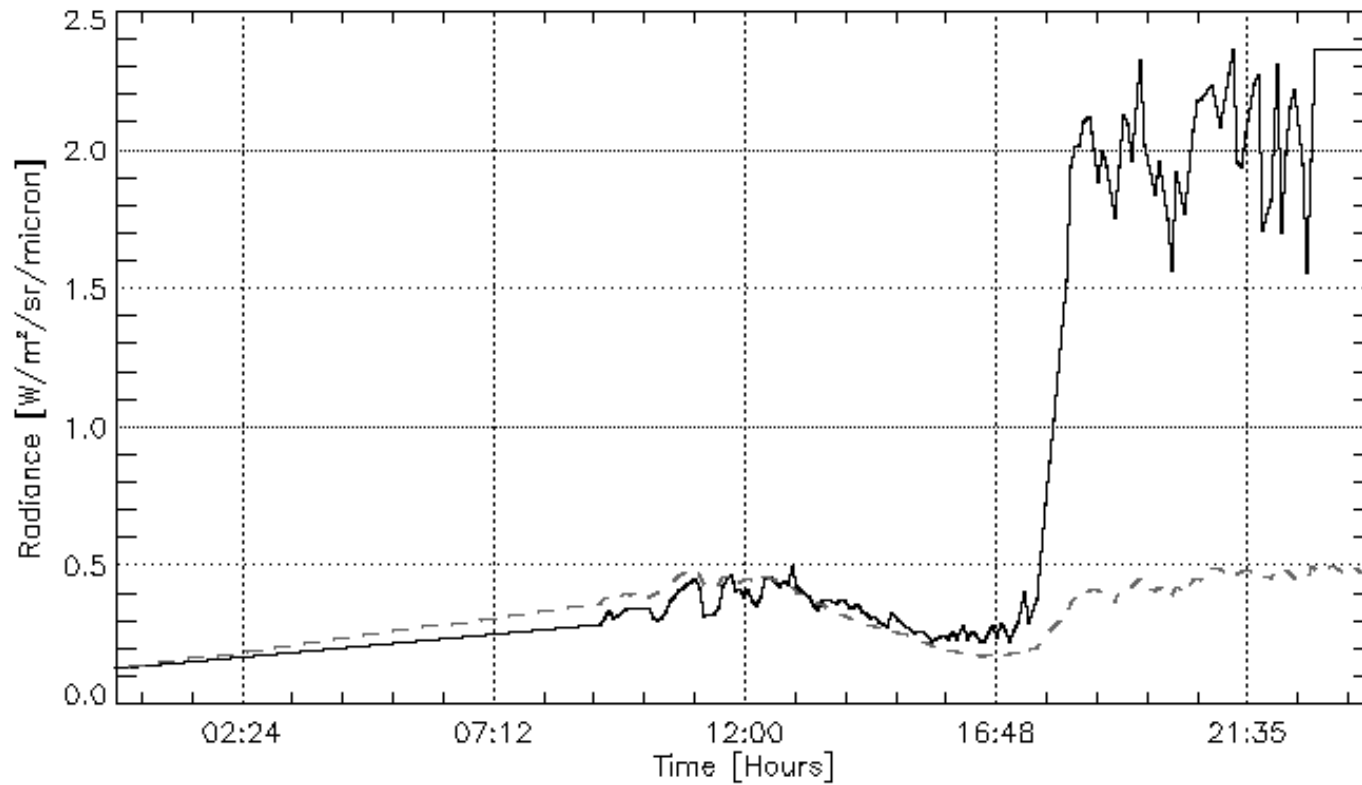
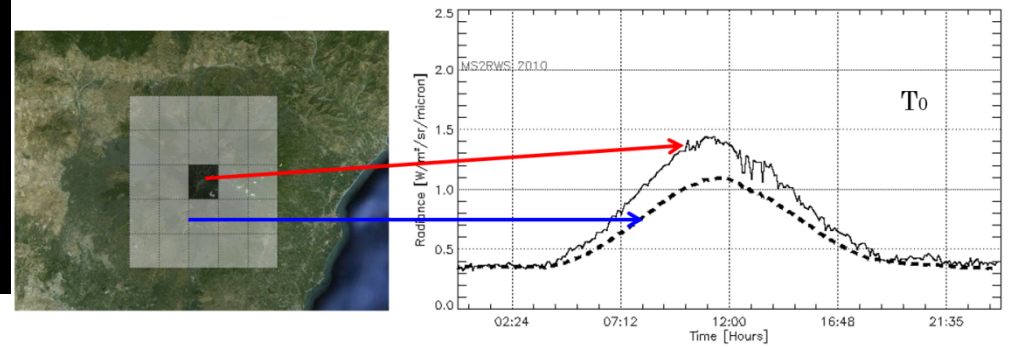
NO  
Eruption



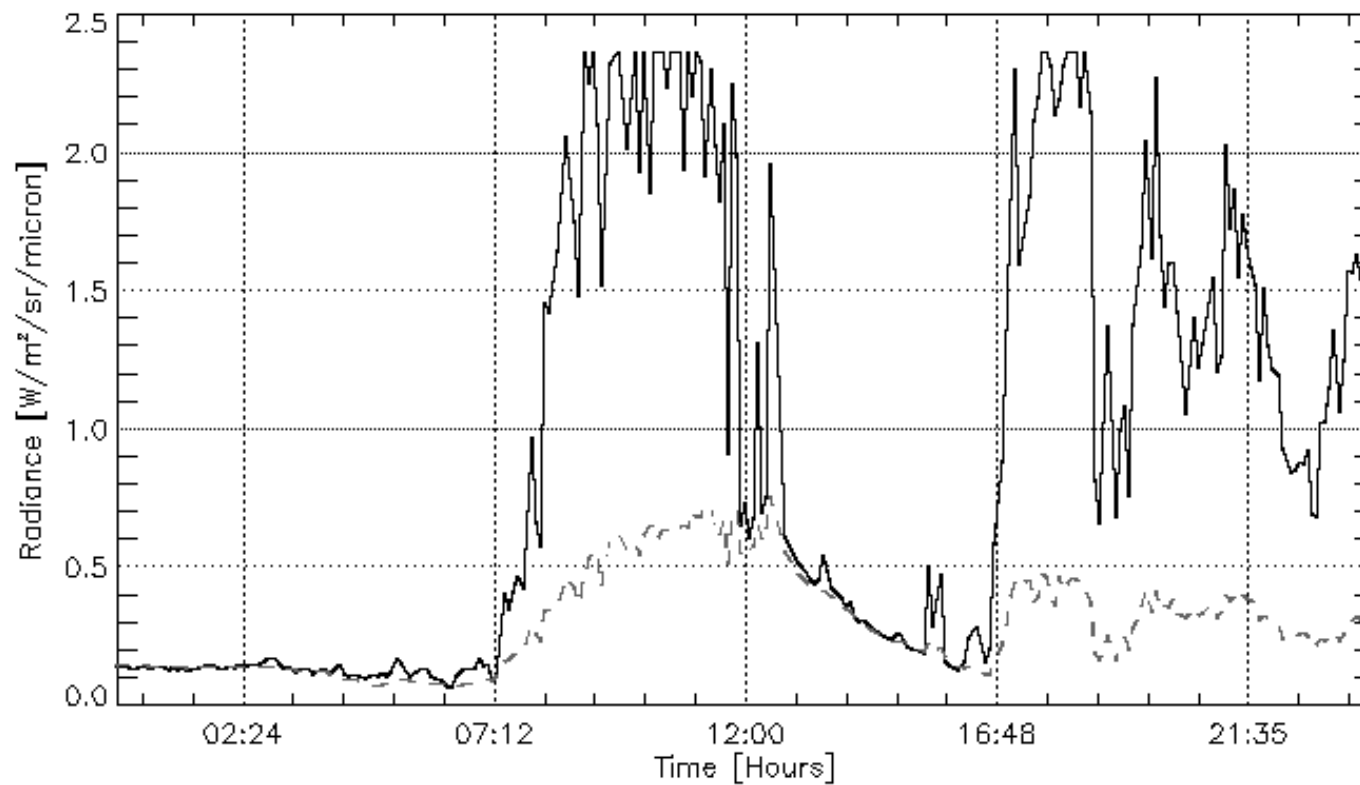
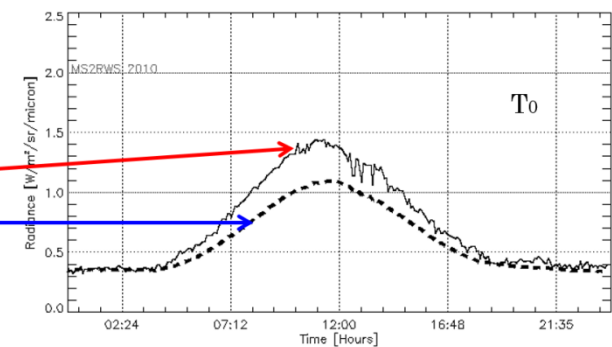
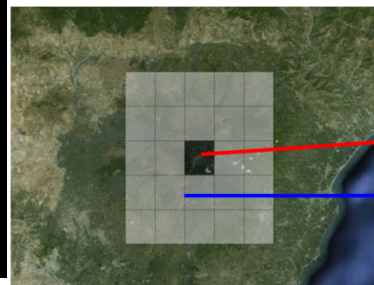
Eruption



# 2017 February 27 Etna eruption



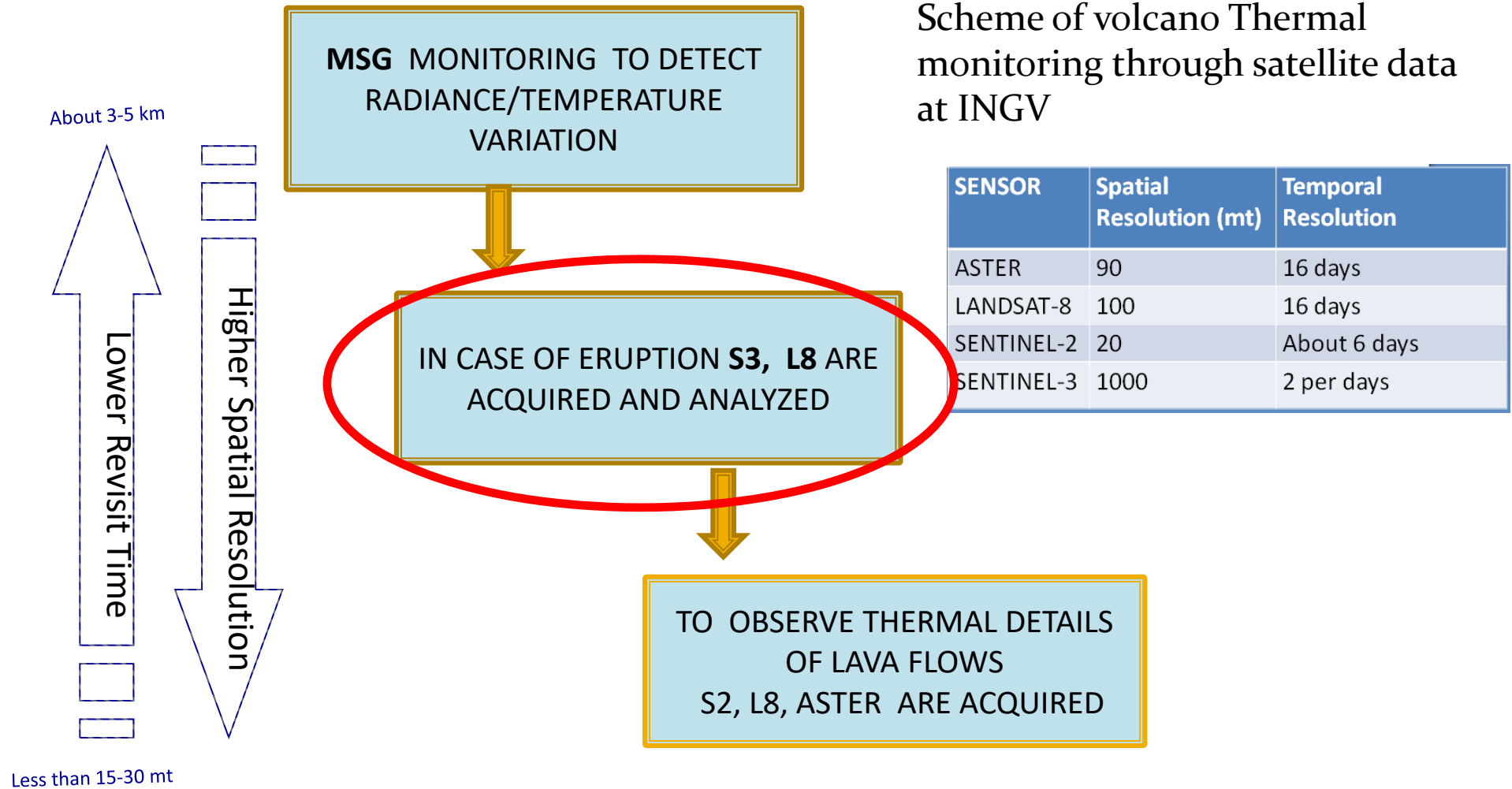
# 2017 March 15





# Multi scale and multi temporal satellite monitoring

Scheme of volcano Thermal monitoring through satellite data at INGV



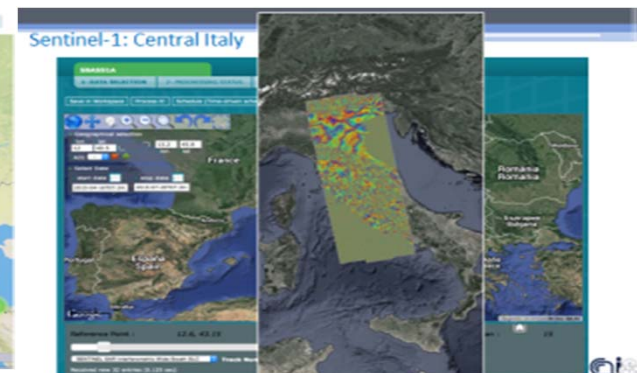
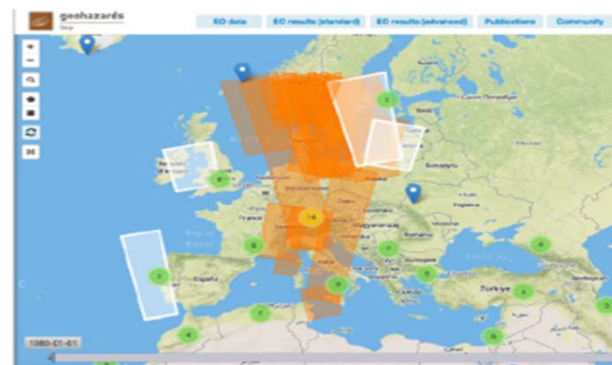
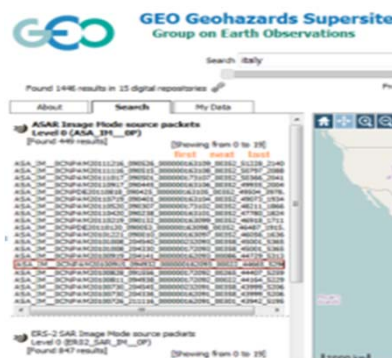
# ESA Geohazards Exploitation Platform (GEP)



ESA funded the development of an innovative tool (GEP) to demonstrate the benefits of a satellite data exploitation platform for large scale hazards mapping and monitoring and to link with Science and User networks.

## The GEP Platform allows

- on demand processing for specific user needs and systematic processing to address common information needs of the geohazards community as a whole
- massive processing on multi-tenant computing resources on the Cloud that will address the challenges of monitoring tectonic areas on a global basis, and of studying a range of geohazards.



# GEP and STEMP

- In the context of the VOLcanoes Thermal Application (VOLTAGE) for GEP has been implemented.
- INGV has setup an end-to-end processing chain (STEMP) for the generation of surface temperature maps over volcanic areas.
- STEMP generates:
  - Surface temperature map from ASTER, Landsat-8, Sentinel-3 (volcanic activity early warning studies)
  - Hot Spot and Lava flow detection with Sentinel-2.

# VOLCANOES SELECTED FOR TO TEST STEMP PRODUCTS (1/2)

Selection for GEP [Y / N / M]	Volcano	Area	Country	Region	Elevation
N	<u>Fogo</u>	Fugo Island	Cape Verde	Africa	2829 m
Y	<u>Puyehue-Cordón Caulle</u>	Región de Los Ríos	Chile	Latin America	2236 m
Y	<u>Arenal</u>	Alajuela	Costa Rica	Latin America	1670 m
Y	<u>Poás</u>	Alajuela	Costa Rica	Latin America	2708 m
Y	<u>Turrialba</u>	Cartago	Costa Rica	Latin America	3340 m
Y	<u>La Cumbre / Fernandina</u>	Galápagos, Isla Fernandina	Ecuador	Latin America	1476 m
Y	<u>Sangai</u>	Morona-Santiago Province	Ecuador	Latin America	5286 m
Y	<u>Sierra Negra</u>	Galápagos, Isla Isabela	Ecuador	Latin America	1124 m
N	<u>Wolf</u>	Galápagos, Isla Isabela	Ecuador	Latin America	1710 m
Y	<u>Piton de la Fournaise</u>	La Réunion	France	Africa	2632 m
Y	<u>Santiaguito</u>	Quetzaltenango	Guatemala	Latin America	2550 m
N	<u>Barren Island</u>	Andaman Islands	India	South Asia	354 m
Y	<u>Dukono</u>	Halmahera	Indonesia	SE Asia	1229 m

# VOLCANOES SELECTED FOR TO TEST STEMP PRODUCTS (2/2)

Y	Ibu	Halmahera	Indonesia	SE Asia	1325 m
Y	Merapi	Central Java / Yogyakarta	Indonesia	SE Asia	2968 m
N	Semeru	East Java	Indonesia	SE Asia	3676 m
N	Tengger	East Java	Indonesia	SE Asia	2329 m
Y	Etna	Sicily	Italy	Europe	3330 m
Y	Stromboli	Sicily, Aeolian Islands	Italy	Europe	924 m
Y	Vesuvio Campi Flegrei	Naples	Italy	Europe	458 m
Y	Colima	Colima	Mexico	Latin America	3850 m
N	Bezymianny	Kamchatka	Russia	Europe & Central Asia	2882 m
N	Ol Doinyo Lengai	Rift Valley	Tanzania	Africa	2962 m
N	Kilauea	Hawaii	USA	Oceania	1222 m
N	Ambrym	Malampa Province	Vanuatu	Oceania	1334 m
N	Yasur	Tanna	Vanuatu	Oceania	361 m
Y	Cotopaxi	Cotopaxi Province	Ecuador	Latin America	5911 m
Y	Tungurahua	Tungurahua Province	Ecuador	Latin America	5023 m
Y	Reventador	Napo Province	Ecuador	Latin America	3562 m
Y	Cotacachi	Imbabura Province	Ecuador	Latin America	4944 m
N	Pichincha	Pichincha Province	Ecuador	Latin America	4784 m
Y	Sinabung	Sumatra Utara Province	Indonesia	SE Asia	2460 m
Y	Chachimbiro	Imbabura Province	Ecuador	Latin America	4106 m

# Volcano location Map

60 -150 -140 -130 -120 -110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180



# INGV-STEMP implementation on Geohazards Exploitation Platform (GEP)

The screenshot displays the Geohazards TEP web application interface. The browser address bar shows the URL: `geohazards-tep.esa.int/geobrowser/#!&context=Landsat+8`. The application header includes the logo, user name 'msilvestri', and navigation tabs for 'EO data', 'EO-based products', 'Publications', and 'Community'. A search bar labeled 'EO Free Text Search' is positioned above a map of Europe and the Middle East. The map shows satellite swaths and a search area. Below the map, a search results list is visible, showing multiple entries for 'Entity ID: LC08\_L1GT\_052212\_20171129\_20171129\_01\_RT' and 'Entity ID: LC08\_L1TP\_189034\_20171129\_20171129\_01\_RT'. The right sidebar contains a 'Processing Services' panel with a search bar and a grid of service icons, including GAMMA Level-0, PF-ERS, SRTM Digital Elevation Mo..., ADORE DORIS interferom..., Repeat Orbit Interferometr..., StaMPS Permanent Scatte..., GMTSAR interferometric p..., InSAR SBAS, and STEMP-L8.

# GEP: Data List (e.g.L8)

The screenshot displays the Geohazards TEP web application interface. At the top, the browser address bar shows the URL `geohazards-tep.esa.int/geobrowser/#!&context=Landsat+8`. The application header includes the logo, user name `msilvestri`, and navigation tabs for `EO data`, `EO-based products`, `Publications`, and `Community`.

The main content area features a map of the Mediterranean region, centered on Italy and Greece. The map shows satellite data overlays with orange grid lines. A search bar at the top left contains the text `EO Free Text Search` and a `spatial` filter. A date range selector at the bottom of the map shows `2013-03-09` to `2017-11-29`. The map coordinates are `Lon: 28.895 Lat: 42.196`.

On the right side, there is a `Processing Services` panel with a search bar and a grid of service icons. The services listed include:

- GAMMA Level-0
- PF-ERS
- SRTM Digital Elevation Mo...
- ADORE DORIS interferom...
- Repeat Orbit Interferometr...
- StaMPS Permanent Scatte...
- GMTSAR interferometric p...
- INSAR SBAS
- STEMP-L8

At the bottom, the `Current search result` section shows a list of search results for the query `Result for OpenSearch query over type...`. The results are displayed in a table with columns for Entity ID, Acquisition Date, Path, and Row. The first few results are:

Entity ID	Acquisition Date	Path	Row
LC08_L1GT_052212_20171129_20171129_01_RT	29-NOV-17	52	212
LC08_L1GT_052211_20171129_20171129_01_RT	29-NOV-17	52	211
LC08_L1GT_052210_20171129_20171129_01_RT	29-NOV-17	52	210
LC08_L1TP_189034_20171129_20171129_01_RT	29-NOV-17	189	34
LC08_L1TP_189033_20171129_20171129_01_RT	29-NOV-17	189	33
LC08_L1TP_189032_20171129_20171129_01_RT	29-NOV-17	189	32
LC08_L1TP_189031_20171129_20171129_01_RT	29-NOV-17	189	31



# From Data to Product (based on L8)

The screenshot displays the Geohazards TEP web application interface. The main map shows a geographical area in Sicily, Italy, with a red overlay representing a land surface temperature map. The interface includes a search bar, navigation controls, and a processing service panel on the right.

**Processing Services Panel:**

- Service:** STEMP-L8
- Description:** Land surface temperature map (Celsius degrees) obtained by multi-spectral optical sensors (LANDSAT8) generated in GeoTIFF format.
- Job title:** STEMP-L8
- Start date:** [Input field]
- End date:** [Input field]
- Volcano name:** Etna
- Mission:** LANDSAT8
- Select the result:**
  - OpenSearch Description to the Results (application/xml)
  - Result Files Distribution Package (application/xml)
- Run Job:** [Button]

**Search Results:**

Current search result: 1 2

Total results 00

- Result for OpenSearch query over type... Total results 00
- Result 1: STEMP - Surface Temperature Map - LCS1890322017077LGN00 - 2017-03-20T02:24:41Z
- Result 2: STEMP - Surface Temperature Map - LCS1890322017077LGN00 - 2017-03-20T02:21:26Z
- Result 3: STEMP - Surface Temperature Map - LCS1890322017077LGN00 - 2017-03-20T02:20:47Z
- Result 4: STEMP - Surface Temperature Map - LCS1880342017088LGN00 - 2017-03-27T18:59:55Z
- Result 5: STEMP - Surface Temperature Map - LCS1880322017088LGN00 - 2017-03-27T18:50:00Z
- Result 6: STEMP - Surface Temperature Map - LCS1880322017088LGN00 - 2017-03-26T18:28:14Z
- Result 7: STEMP - Surface Temperature Map - LCS1890312017084LGN00 - 2017-03-25T18:28:14Z

# From Data to Product (based on S2)



STEMP-S2 in case of eruption with Sentinel-2 data



The screenshot displays a web-based geospatial application. On the left, a map shows the Etna volcano area with a red hot spot. A blue arrow labeled "Results" points from the map to the processing services panel on the right. The panel shows job details for "STEMP-S2", including job name, WPS Job ID, Remote ID, start date (Jul 19th 2017), and status (Success). Below the job info, there is a "Parameters" section and a "Success" message: "The job was completed successfully". At the bottom of the panel, there is a "Show results" button and an "XML Result" section. In the bottom left, a list of search results is visible, with the first result being "STEMP - HOT-SPOT detection". A metadata popup is shown at the bottom center, providing details for the "STEMP - HOT-SPOT detection" product, including title, date, volcano (Etna), satellite (Sentinel-2), DEM Spatial Resolution (20m), HOT SPOT description (Hot pixels (red), very hot pixels (yellow)), and producer (INGV).

Processing Services  
STEMP-S2

Job Info

Job Name STEMP-S2  
Wps Job id 89a9f9acc-2a6f-4532-9a05-69c436740797  
Remote id fbaeadc2-9086-493e-895d-7589583bad57  
Started at Jul 19th 2017  
Created by Malvina Silvestri  
Status/Result Location  
Status Success  
Visibility private  
Share

Parameters

Name	Value
startdate	2017-03-26
enddate	2017-03-26
volcano	Etna

Success  
The job was completed successfully

Show results

XML Result

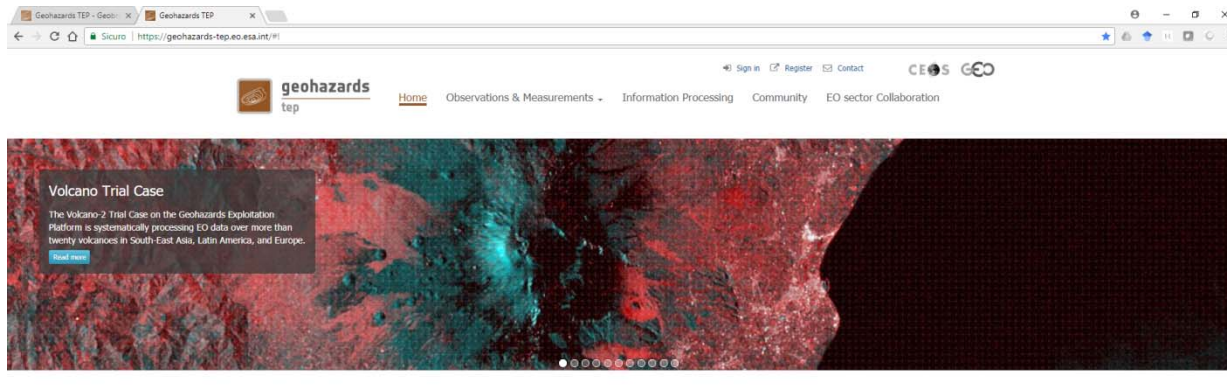
STEMP - HOT-SPOT detection

title	STEMP - HOT-SPOT detection
date	2017-03-26T09:40:31.029000Z
Volcano	etna
Satellite	Sentinel-2
DEM Spatial Resolution	20m
HOT SPOT	Hot pixels (red), very hot pixels (yellow)
Producer	INGV

Published Jul 19th 2017

Metadata info on output product

# https://geohazards-tep.eo.esa.int/#!



DISCUSS Volcano Trial Case on GEP: Systematically processing EO data  
| gep-blog

Blog (full archive)

#### Operational monitoring on GEP of volcanic eruptions and their impact on agriculture and vegetation

Since January 2017, operational monitoring of 22 worldwide volcanoes has been available on the Geohazards Exploitation Platform of ESA (GEP), thanks to the activities conducted in the VEGAN project and in partnership with the GEP project, an activity originated by ESA concerning hosted processing.....  
4 days ago

#### Interferograms processed by the DLR's High Resolution InSAR browse depict deformations after the November 12, 2017 M 7.3 earthquake at the Iran-Iraq border

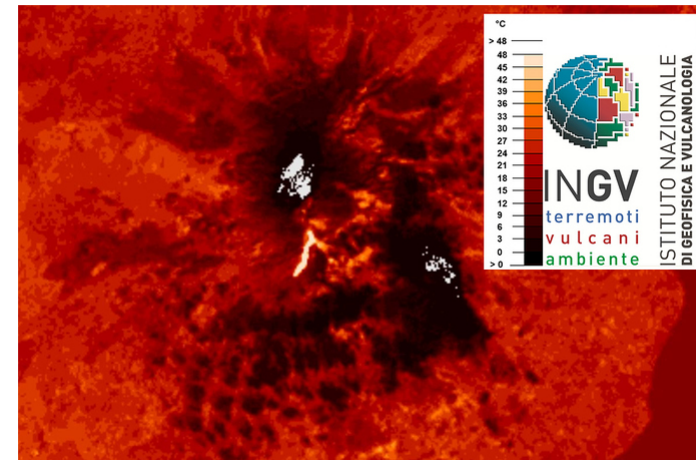
The November 12, 2017 M 7.3 earthquake struck near the Iran-Iraq border in northwest Iran (220 km northeast of Baghdad, Iraq), killing more than 400 people and injuring thousands more. A few days after the earthquake the DLR High Resolution InSAR browse

News

**ESA EarthObservation** @ESA\_EO  
@EUAgri launched yesterday their view on 'The Future of Food & Fibre'. Satellites are a major part of their...  
18 minutes ago

**ESA EarthObservation** @ESA\_EO  
RT @AschbacherJosef: @esa @Janwoerner and @RollsRoyce sign...  
31 minutes ago

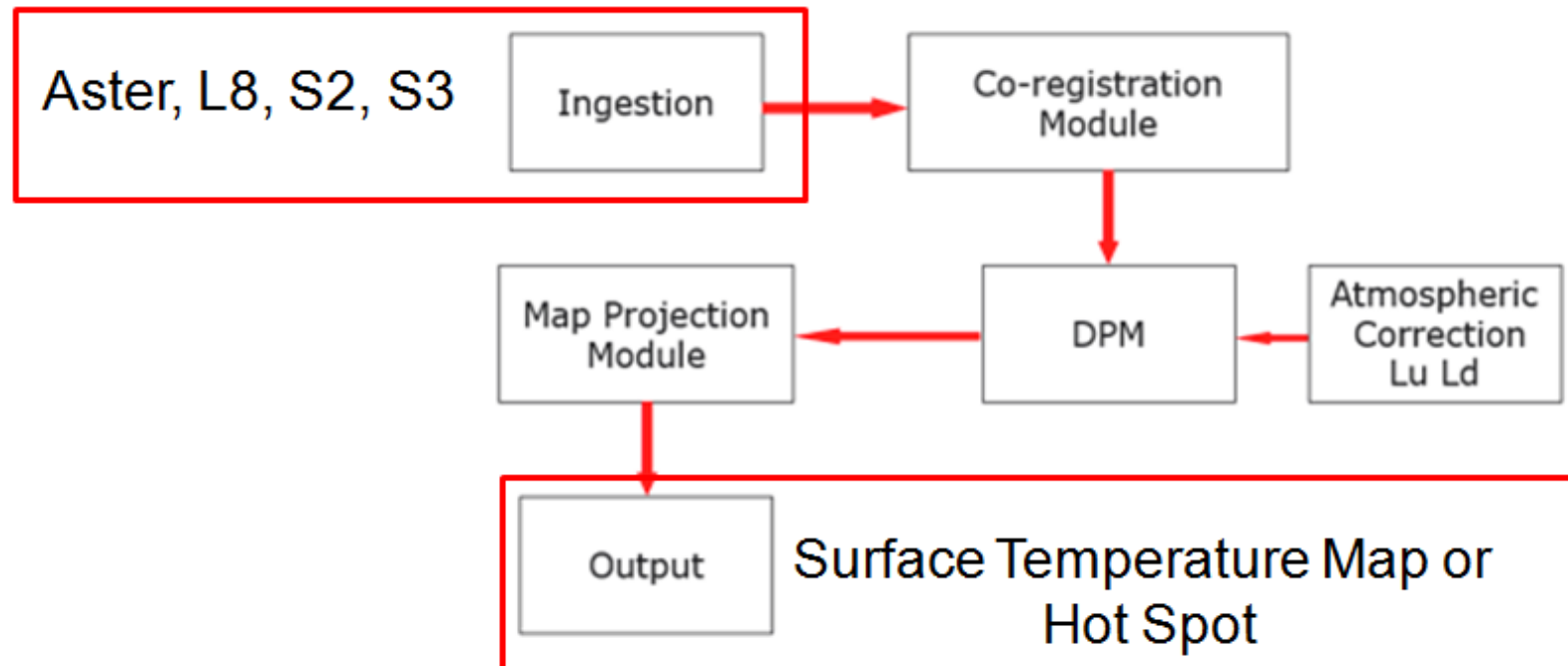
**ESA EarthObservation** @ESA\_EO  
RT @PROBAVegetation: And suddenly it's already December 🍂. Do order your copy of the new #ProbAVV calendar 2018 at https://t.co...  
31 minutes ago



**Figure 2:** Surface Temperature Map of 27th March 2017 of the volcano Etna. It was created with the INGV STEMP service, a systematic processing chain on GEP. The lava flow in bright white-yellow is clearly visible in the middle of the image.

# Data and methods

- DEM for the topography
- In situ atmospheric parameter data to remove the effect of the atmosphere on the EO satellite data.
- **Surface Temperature Map** produced following Gillespie et al., (1998), Barsi et al., (2003) using TIR channels
- **Hot Spot Map** produced following Murphy et al., 2016 using VNIR-SWIR channels

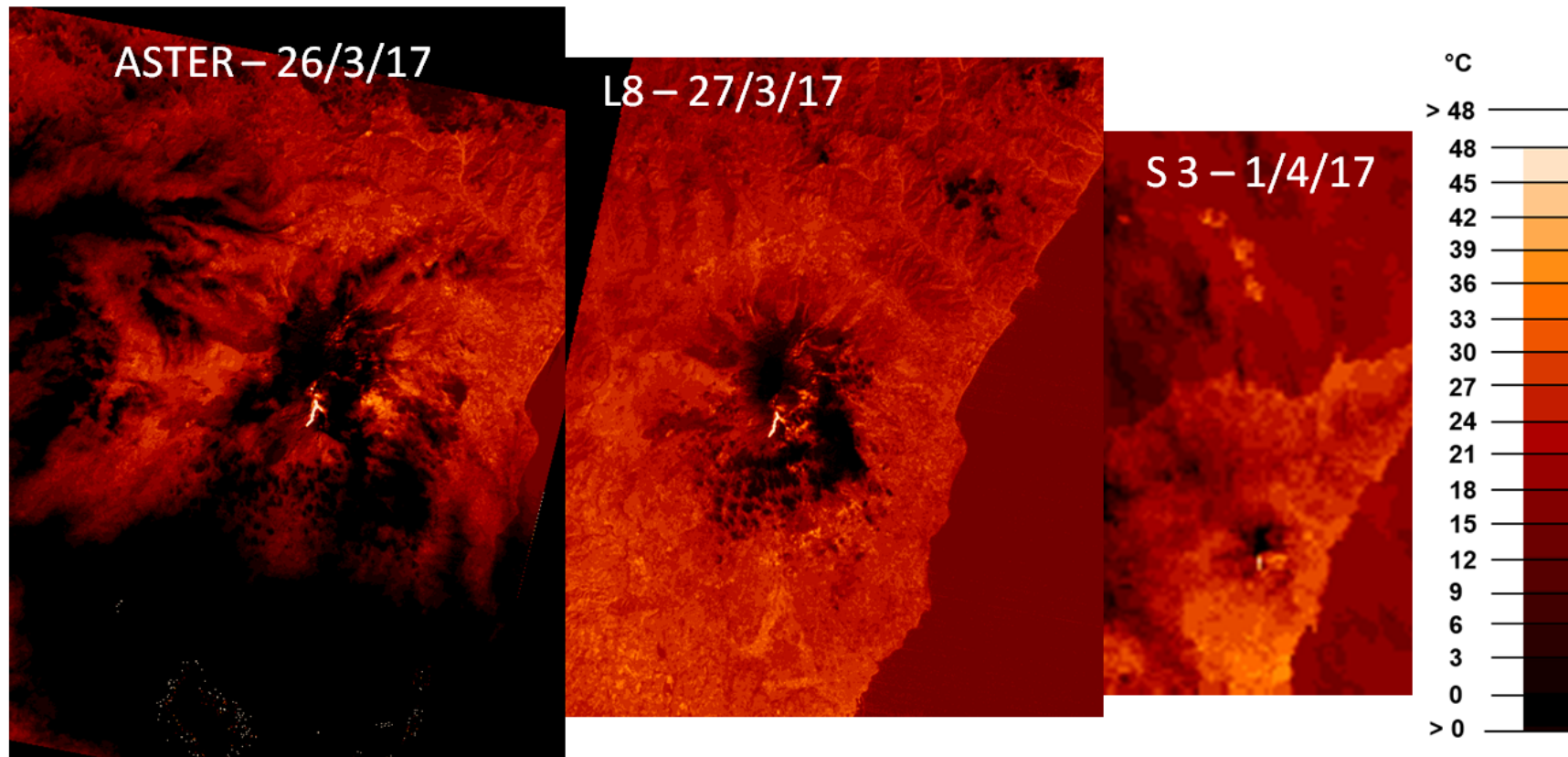


# Surface Temperature map: Temperature Emissivity Separation

- Atmospheric correction using MODTRAN and daily atmospheric profile have been considered
- For this analysis the images acquired during the nighttime pass have been considered because the “contamination” of reflected solar radiation is not present.

# Surface Temperature map comparing different satellite data

Surface temperature using ASTER, L8, S3 on Mt. Etna volcano during the last eruption in 2017(daytime acquisition)

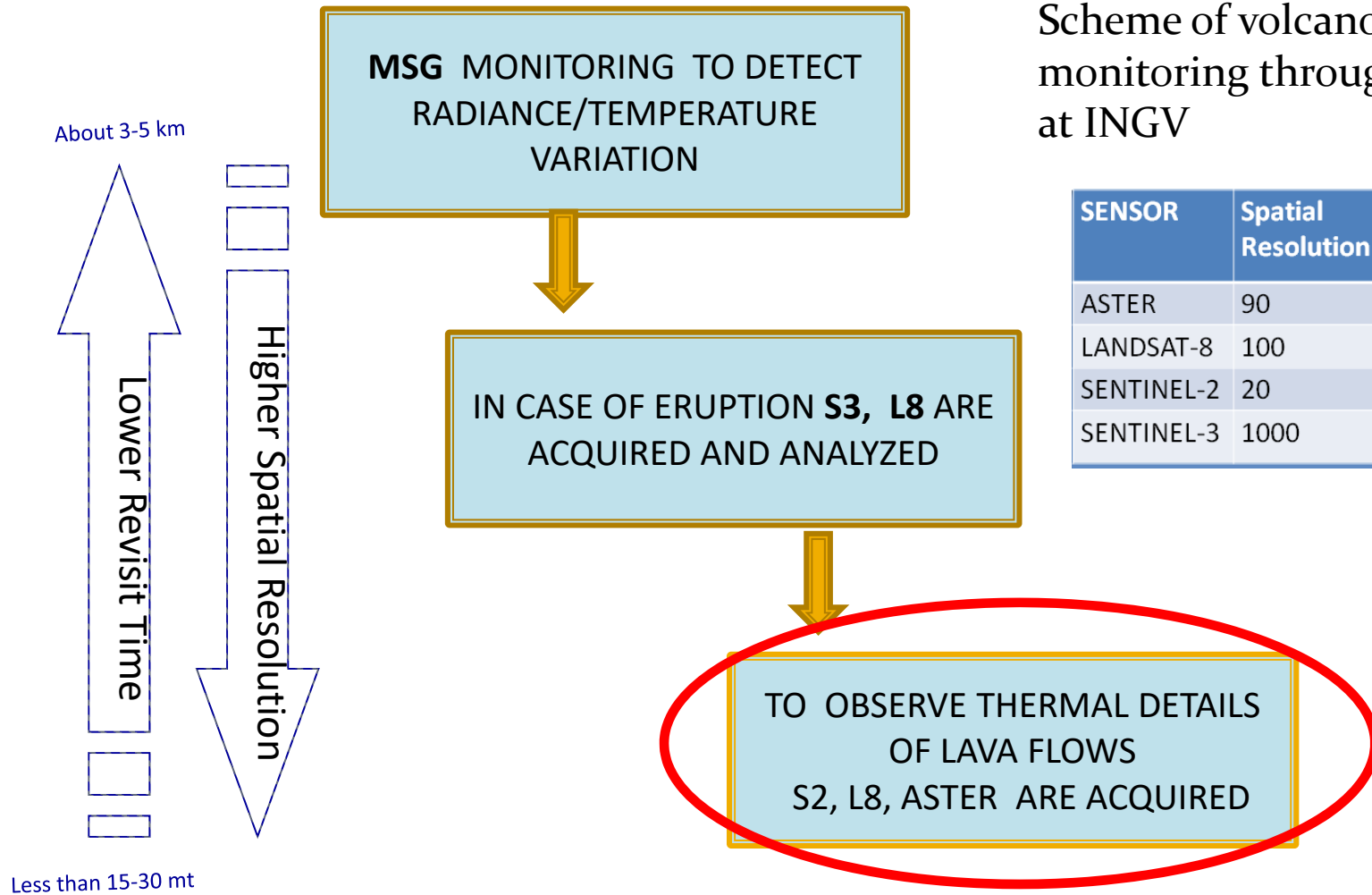


# Results:

- ASTER and L8 have been scaled at ASTER-TIR channel spatial resolution (90 m).
- Using two different methods (TES, BARSIS) the difference in retrieved temperature show an average of less than  $1^{\circ}\text{C}$  for Mt Etna. Comparison with ground measurements also demonstrated good agreement considering that ground measurements represent very small areas compared to the satellite pixel size.
- The results obtained are very useful to understand variability of LST retrievals by remote sensing data
- They highlight the importance of precise emissivity inputs to the retrieval procedures as well as the needs of systematic calibration areas for LST satellite retrievals

# Multi scale and multi temporal satellite monitoring

Scheme of volcano Thermal monitoring through satellite data at INGV





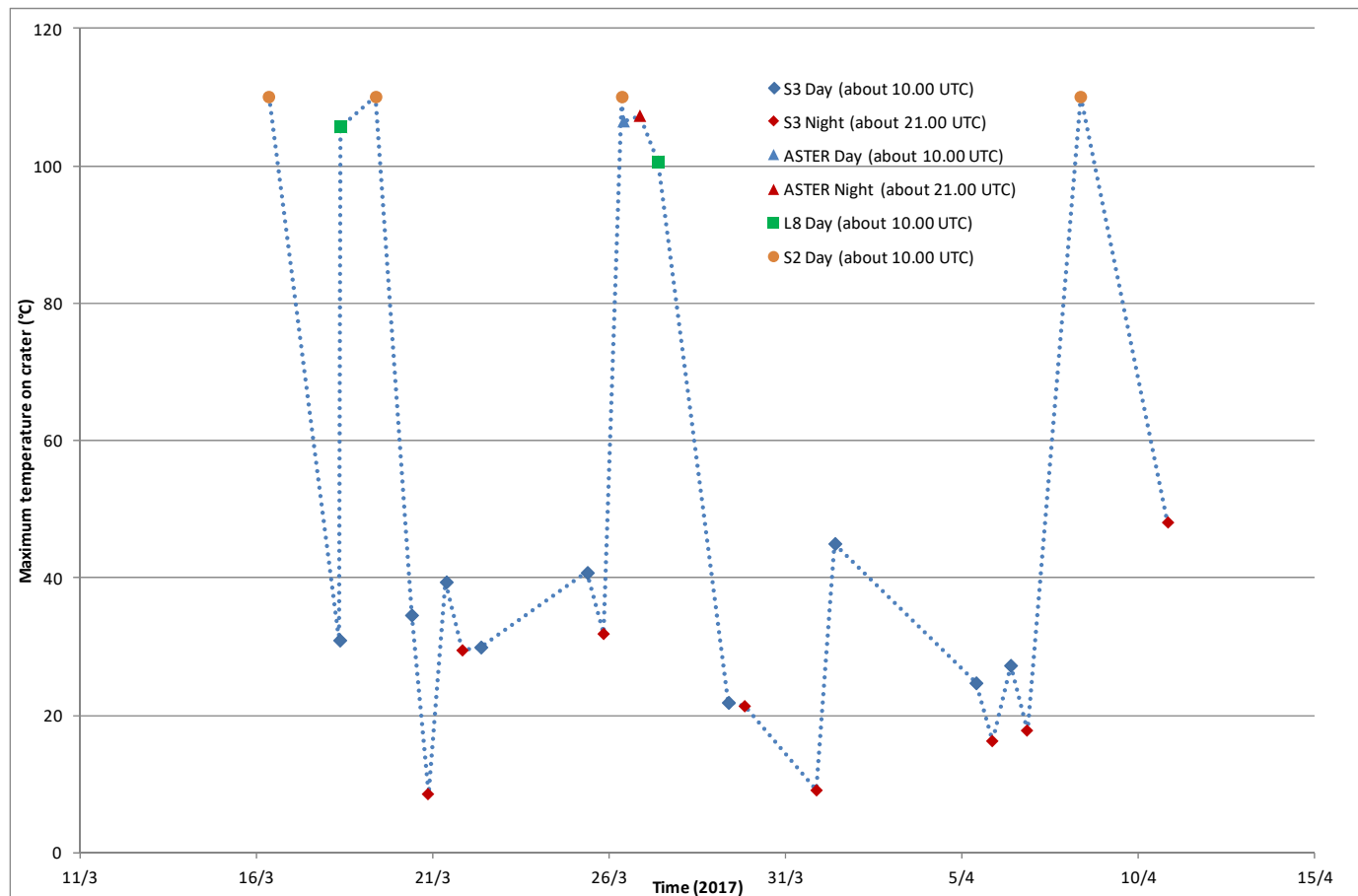
# Hot Spot Map: applied to S2 data

A Procedure to define the area of an active lava flow has been developed within the GEP platform by using the approach proposed by [Murphy et al., 2016] and applied to SENTINEL 2 and S8 data (VIS-SWIR channels)

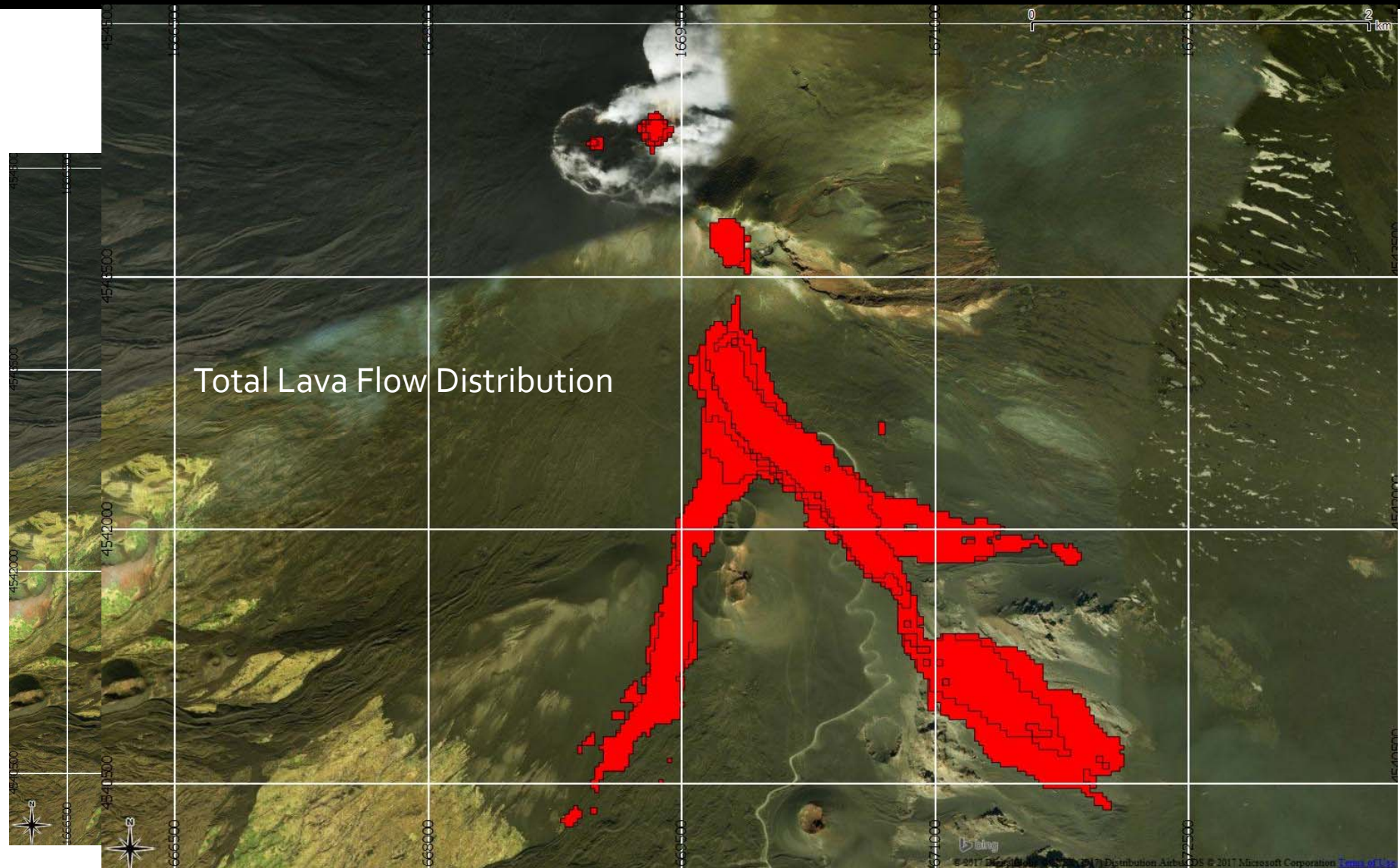
SENTINEL 2 channels  
and 8A: 0.865 micron and 20 mt resolution  
Band 11: 1.610 micron and 20 mt resolution  
Band 12: 2.190 micron and 20 mt resolution

# ETNA ERUPTION 2017

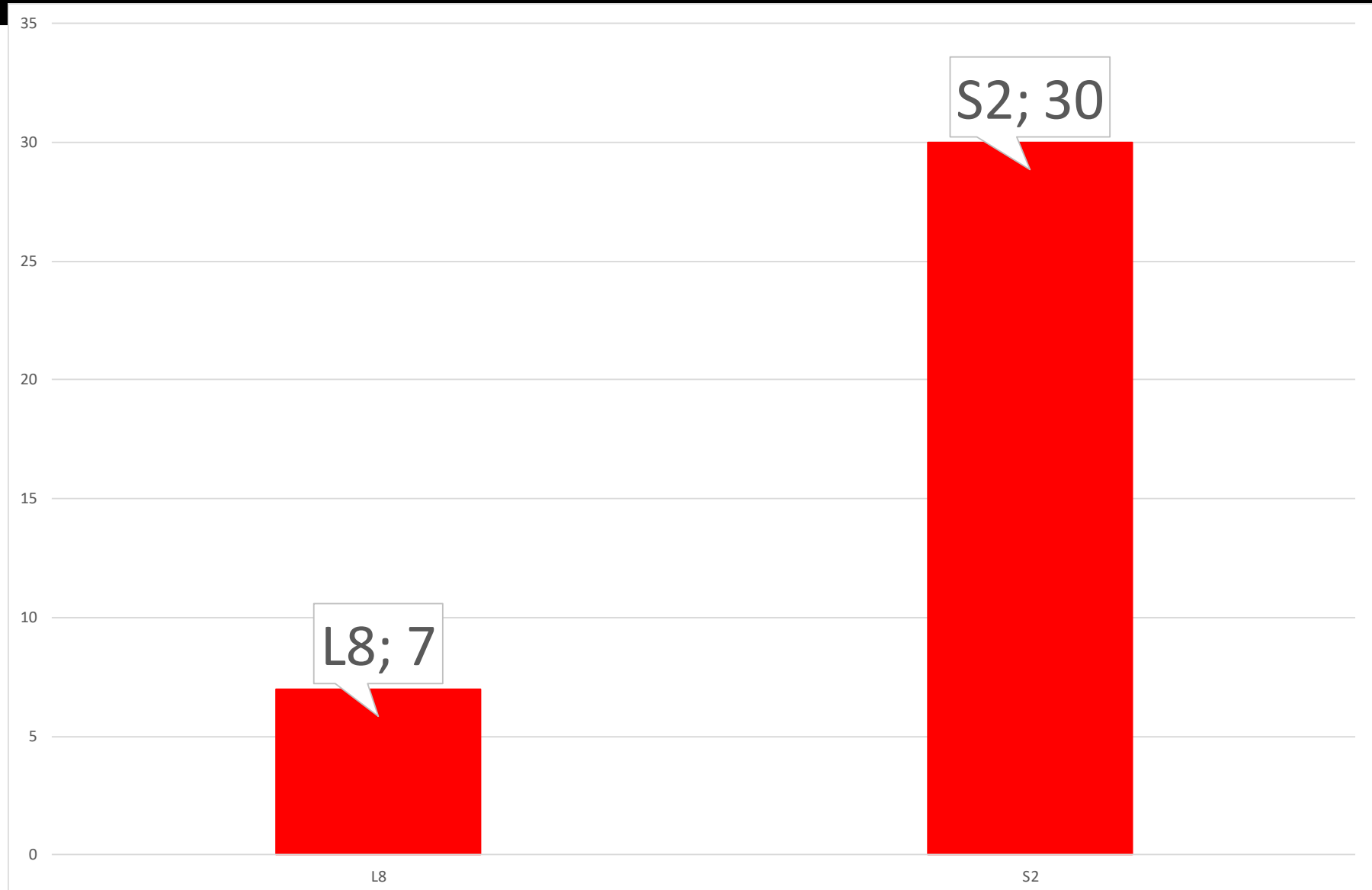
The plot below reports the number of available satellite data for approximately 1 month during last Etna eruption February-April 2017



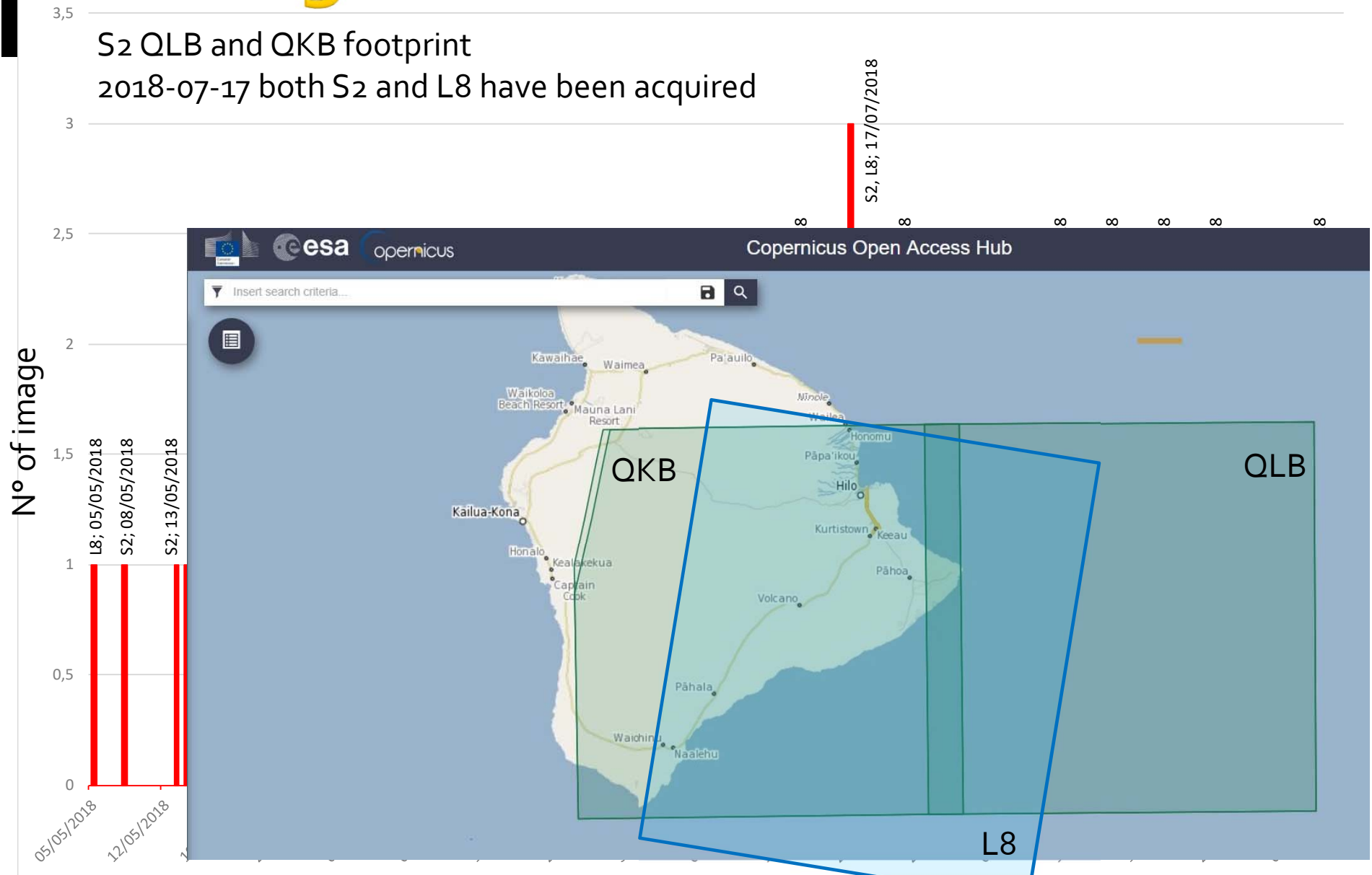
# sin-Eruption Hot Spot and Lava flow detection



# Kilauea Leilani 2018 eruption



# Timing of L8 and S2 data



# May June July August



## Further development: surface temperature time series

In the frame of ESA-GEP project a time series will be produced using co-registered EO data which will allow to digging/drilling the temperature evolution of each pixel in the scene and therefore support the studies on volcanic activity phases.

# Final Considerations

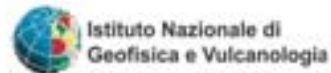
- The NRT data acquired by Geostationary satellites acquiring MWIR-LWIR data offers the capability to set up a NRT operational procedure for early detection of volcanic eruption.
- free, full and open data policy adopted by NASA and ESA in the COPERNICUS program has greatly improved the development of scientific algorithms and monitoring procedures for volcanic activity at global level. The ESA GEP platform proved to be a very useful to test the rapid access to multi data and products
- The combined use of sensors with high revisit time (S3 and MSG-SEVIRI) and high spatial resolution (ASTER, L8 and S2) offers the possibility to generate an improved service detecting the beginning of an eruption and following the lava flow and the estimation of surface temperature suitable for further modeling.



# VEGAN (Volcanic eruption impact on vEgetation and aGriculture using eArth observationN data)



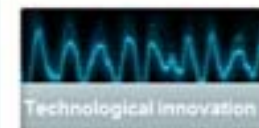
Innovating to protect our World's Life



## VEGAN (Volcanic eruption impact on vEgetation and aGriculture using eArth observationN data)

VAE Next Generation EO-based Information Services

Final Meeting  
November 24th, 2017










# VEGAN project objective

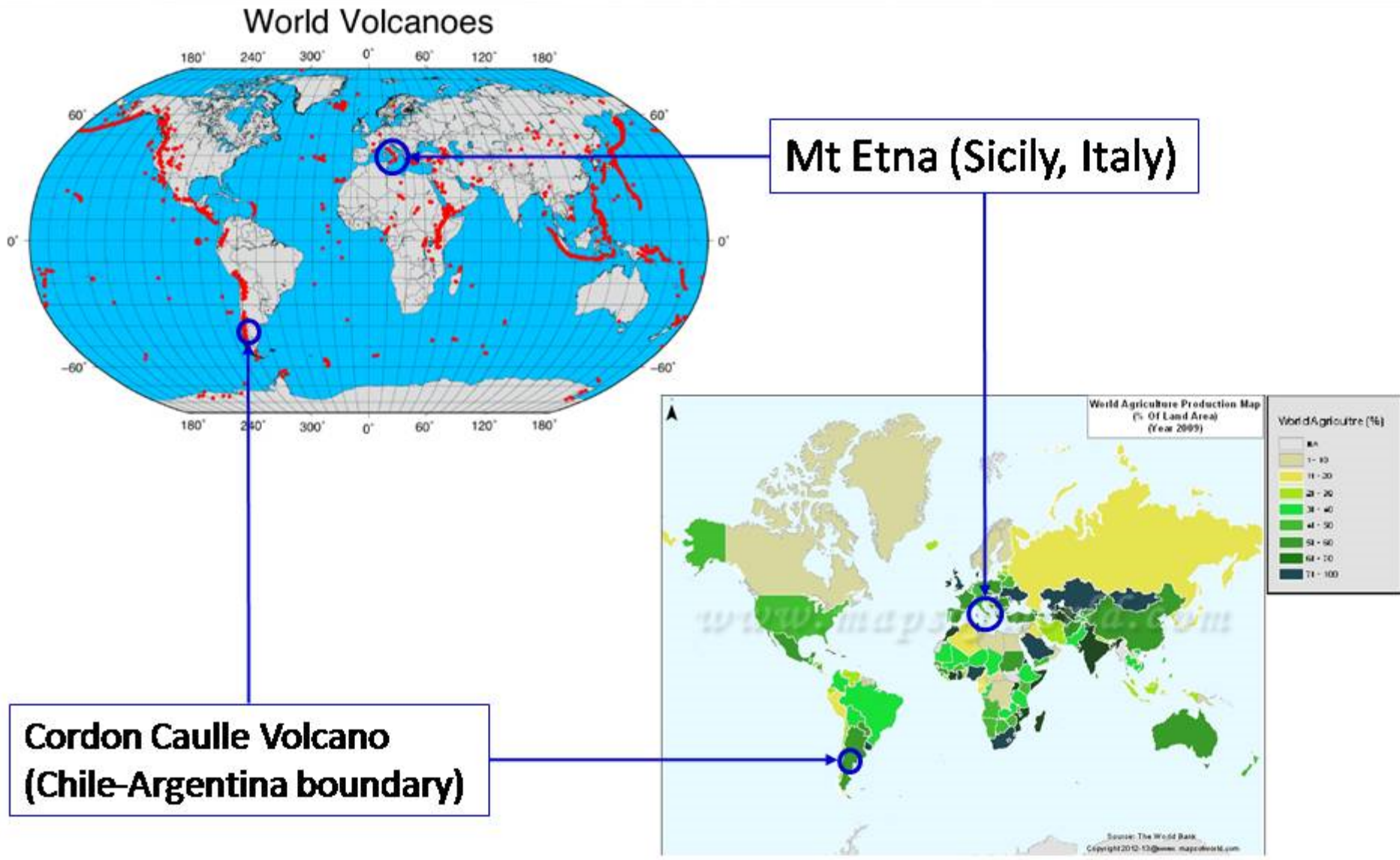
**The aim of VEGAN is to develop innovative products dedicated to the assessment of the impact on vegetation and agriculture of the volcanic eruptions.**

- Unique solution benefiting from the Sentinel data availability
- Taking advantage from the Geo-hazard Exploitation Platform supported by ESA
- Pre-operational test and validation with end-users
- First viability assessment for service development and furniture



# Overview of the products

Product	Data source	Pre-crisis	Crisis	Post-crisis
Eruption detection	MSG-SEVIRI, GOES			
Ash detection	MSG-SEVIRI, MODIS			
Ash dispersion model and fall out map	EROS-USGS, GFS			
Hot spot map	Sentinel-2			
Vegetation vigor map	Sentinel-2			



CEOS meeting, Spetember 5-6 2018, Napoli

# VEGAN involved end-users

## Initially involved end-users

- ▲ Parco del'Etna (Italy)
- ▲ The Oficina de Riesgo Agropecuario (Argentina)
- ▲ The Laboratorio de Estudio y Seguimiento de Volcanes Activos (Argentina)



PARCO DELL'ETNA



## Additional end-users

- ▲ The University of Costa Rica
- ▲ The Volcanological and Seismological Observatory of Costa Rica
- ▲ The Instituto Meteorologico de Costa Rica



# Test results of VEGAN products

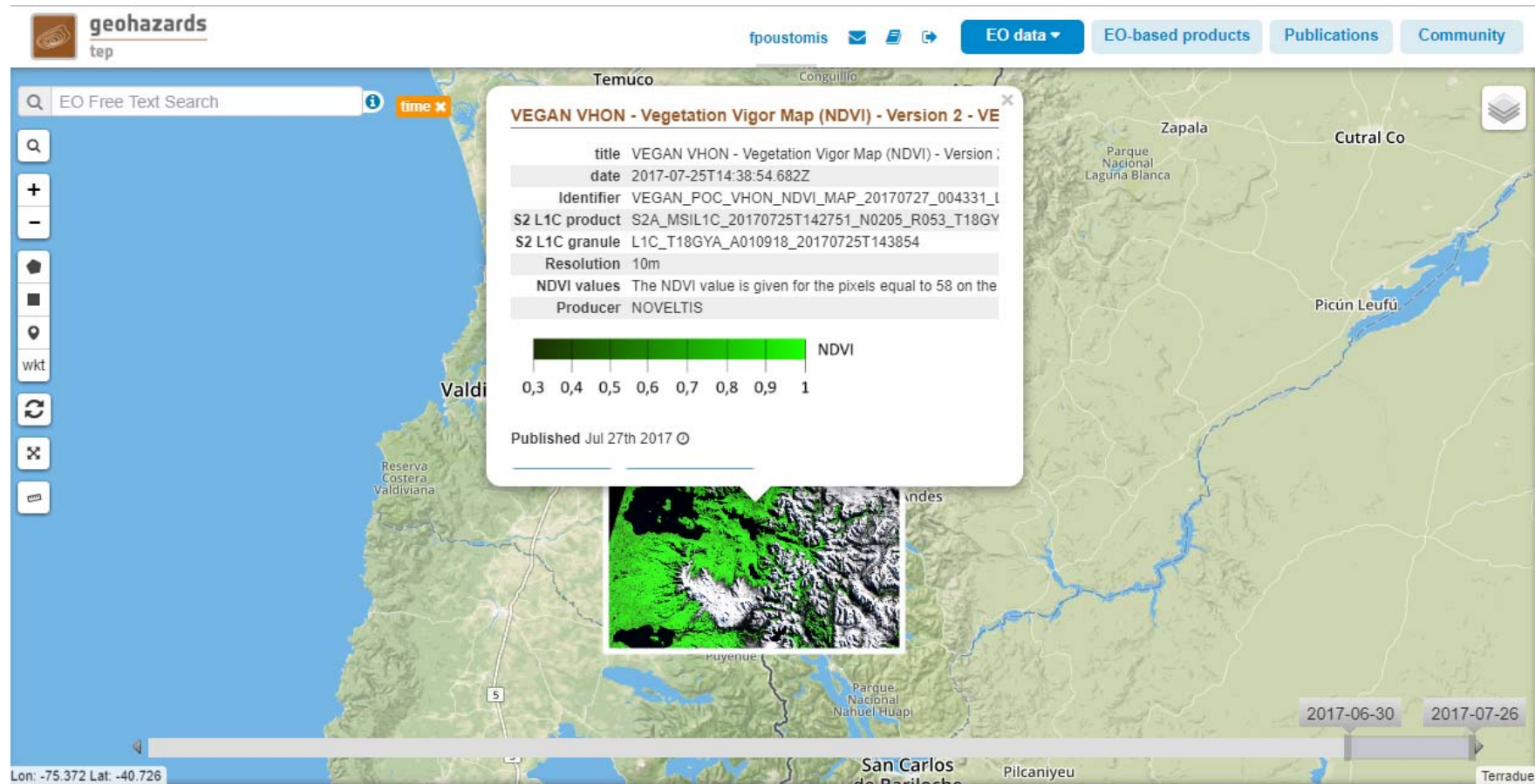
All VEGAN products have been tested and validated successfully

Test ID	Test title	V0	V1	V2
TC-VEGAN-PRC-GO4RSS-001	Detection of beginning of an eruption over Etna volcano	✓	✓	✓
TC-VEGAN-PRC-GO4RSS-002	Detection of beginning of an eruption over Puyehue-Cordón Caulle volcano	✓	✓	✓
TC-VEGAN-CRI-MBTD-001	Ash detection based on MODIS BTD	✓	✓	✓
TC-VEGAN-CRI-MBTD-002	Ash detection based on MSG BTD	✓	✓	✓
TC-VEGAN-CRI-AFOM-001	Ash dispersion fall out map	✓	✓	✓
TC-VEGAN-POC-HSP-001	Application of HSP module on a large wild-fire	✓	✓	✓
TC-VEGAN-POC-HSP-002	Application of HSP module on a non-burning area	✓	✓	✓
TC-VEGAN-POC-HSP-003	Application of the version 2 of HSP module on a volcano after an eruption			✓
TC-VEGAN-POC-VHON-001	Application of VHON module on a scene containing vegetation and other features	✓	✓	✓
TC-VEGAN-POC-VHON-002	Application of VHON module on an AOI with an agricultural field	✓	✓	✓
TC-VEGAN-POC-VHON-003	Application of the version 2 of VHON module on a scene containing vegetation and other features			✓
TC-VEGAN-POC-VHOF-001	Application of VHOF module on time series dataset for an AOI with a scene containing vegetation and other features		✓	✓

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# VEGAN implementation on GEP

- ▲ A lot of effort was invested by NOVELTIS to ensure this implementation.



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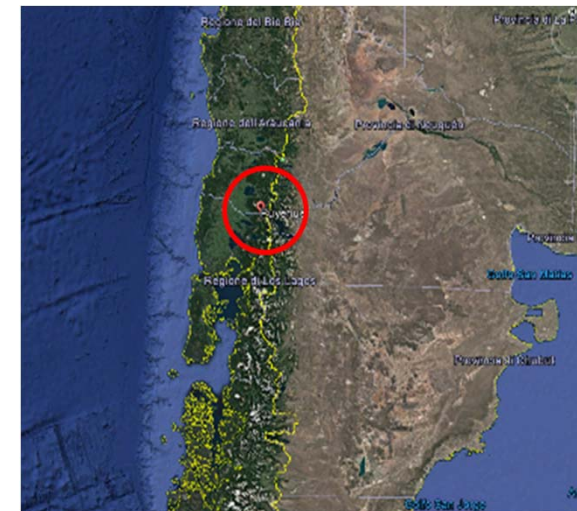
# End user's requirements

## Use case: Puyeu-Cordon Caulle



### PUYEUE-CORDON CAULLE Area of Interest

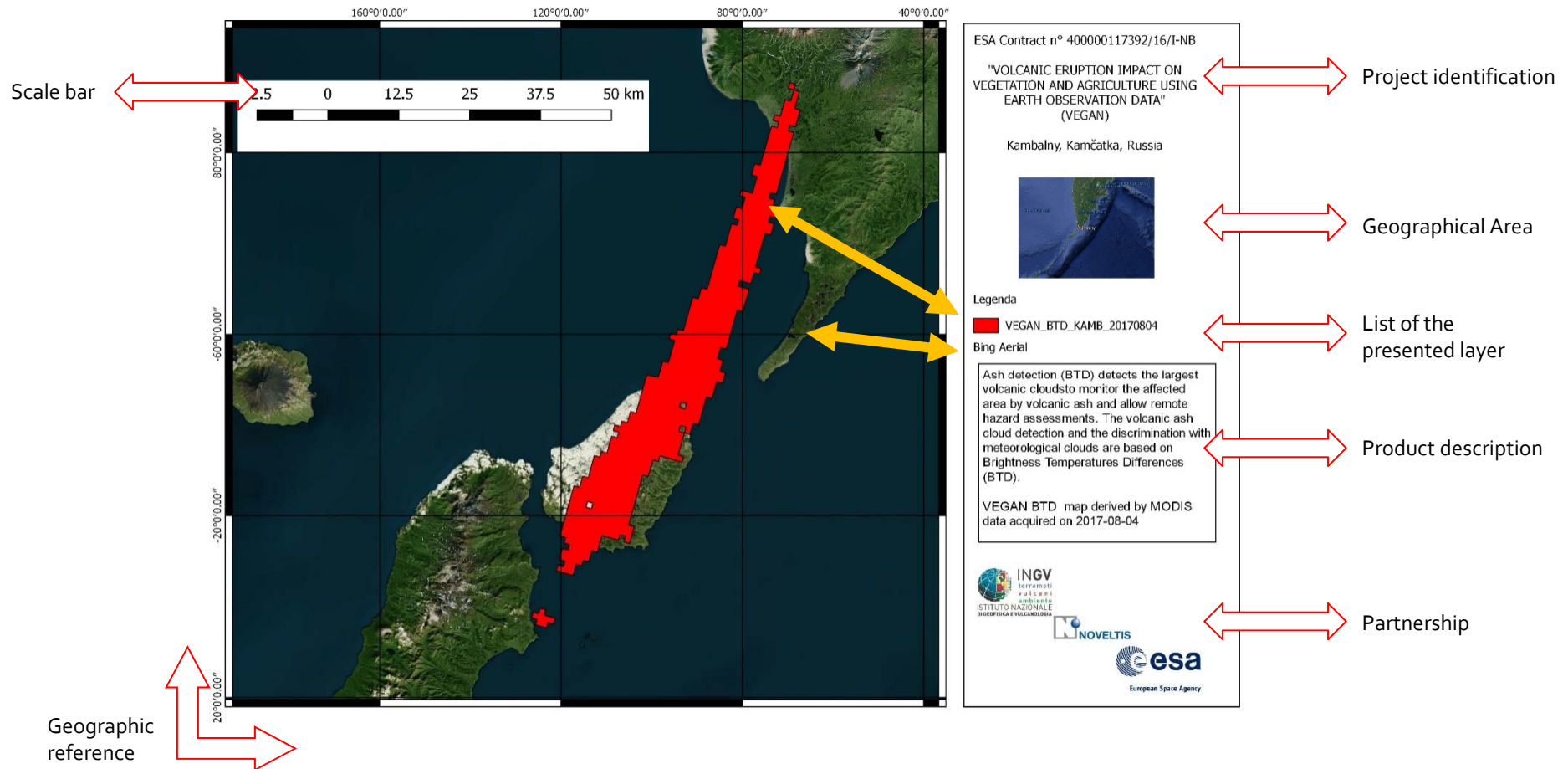
<b>Name:</b>	Región del volcán Cordón Caulle
<b>Type:</b>	<p>Considering the vegetation cover, in Chubut and Río Negro predominate steppes, “arbustivas” and “arbustivo-graminosas”. On the western side of both provinces, there are a wooded zone and other zone with steppes, “arbustiva” and “graminosa-arbustiva”.</p> <p>To the east of Río Negro province, we can find predominantly “estepa arbustiva de monte” and “matorral de monte”. For this reason the provinces involved are principally engaged in the agricultural sector, extensive livestock type.</p>
<b>Description:</b>	<p>The areas has been affected by the 2011 eruption. The provinces of “Río Negro”, “Neuquén” and “Chubut” in Argentina were the most affected, with much of the accumulated ash covered between 0,5 and 5 cm thick area.</p> <div data-bbox="1003 933 1444 1380" data-label="Image"> </div>
<b>Period to be studied</b>	June 2011





# Pilot service demonstration: Interaction with end-users

VEGAN product presentation



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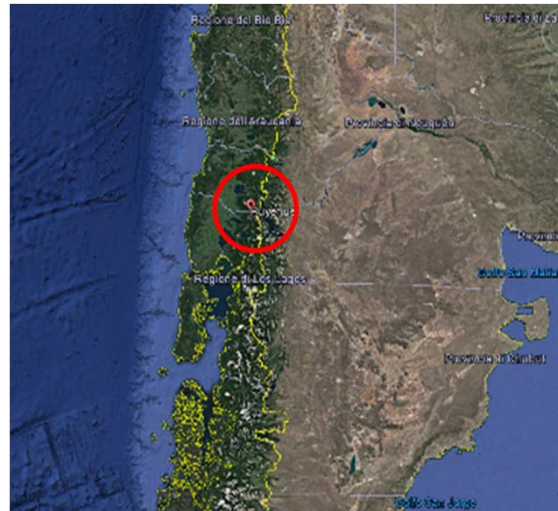
# Use case: Puyeu-Cordon Caulle



- ▲ **Involved end-user:** The Oficina de Riesgo Agropecuario  
The Laboratorio de Estudio y Seguimiento de Volcanes Activos



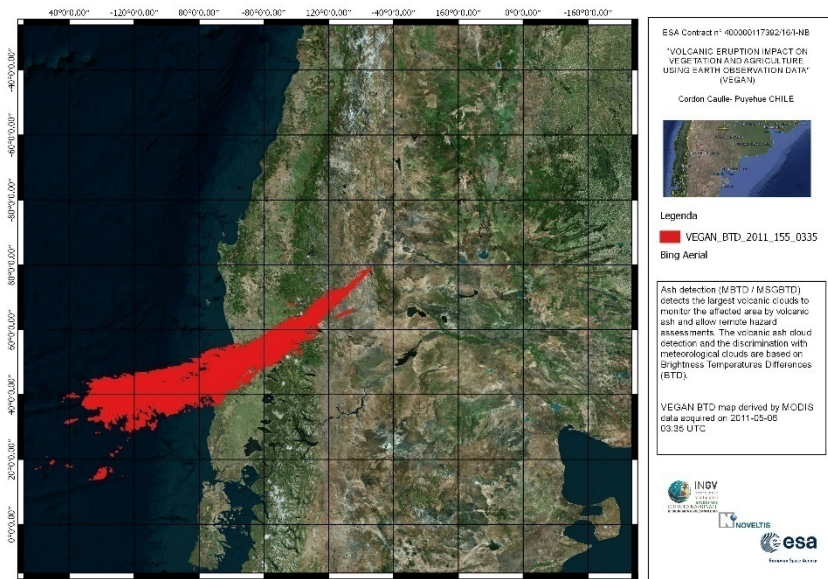
- ▲ **Location:**



- ▲ **Studied event:** eruption of June 2011

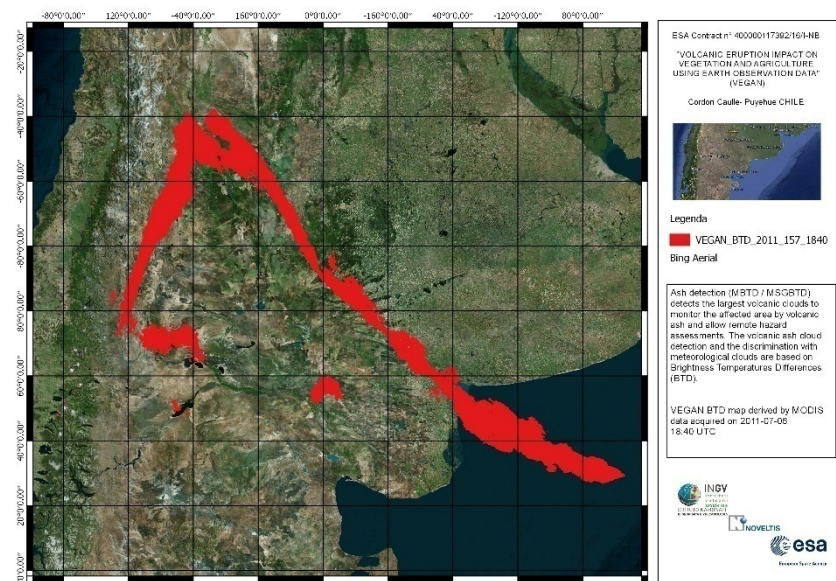
# Use case: Puyeuve-Cordon Caulle

Generated Ash detection in the thermal infrared products



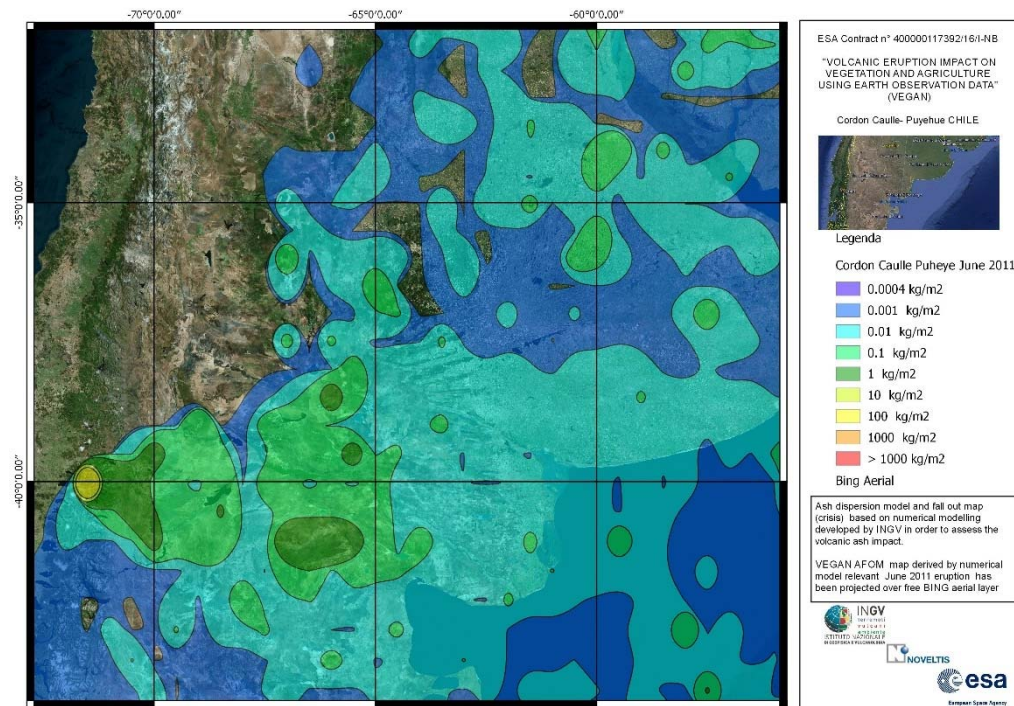
BTD map, June 5<sup>th</sup> 2011,  
03:35 UTC

BTD map, June 7<sup>th</sup> 2011,  
18:40 UTC



# Use case: Puyeuue-Cordon Caulle

Generated Ash fall out map products

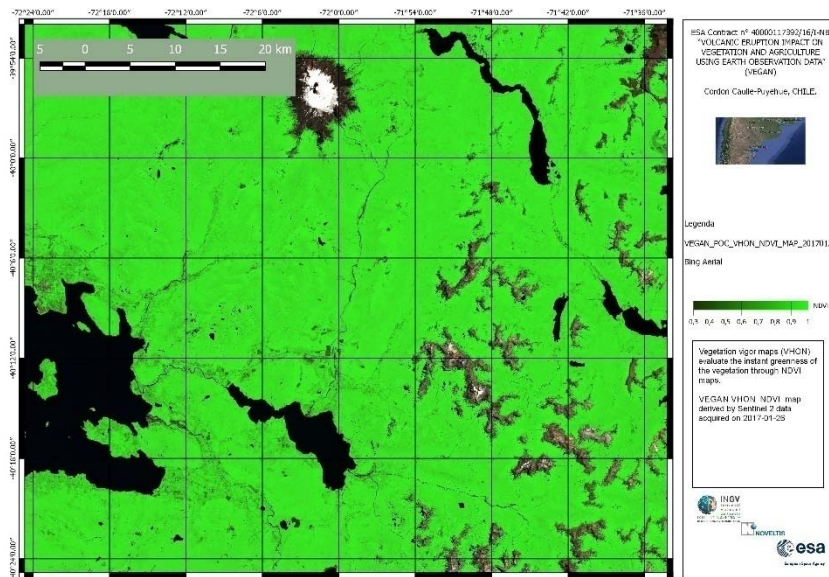


AFOM, June 2011

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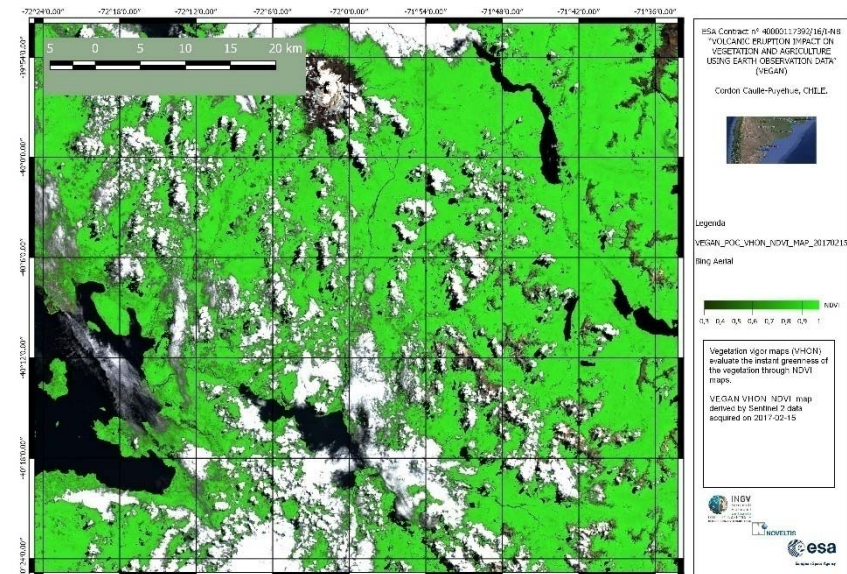
# Use case: Puyeu-Cordon Caulle

Generated Vegetation vigor map products



NDVI map, January 26<sup>th</sup> 2017

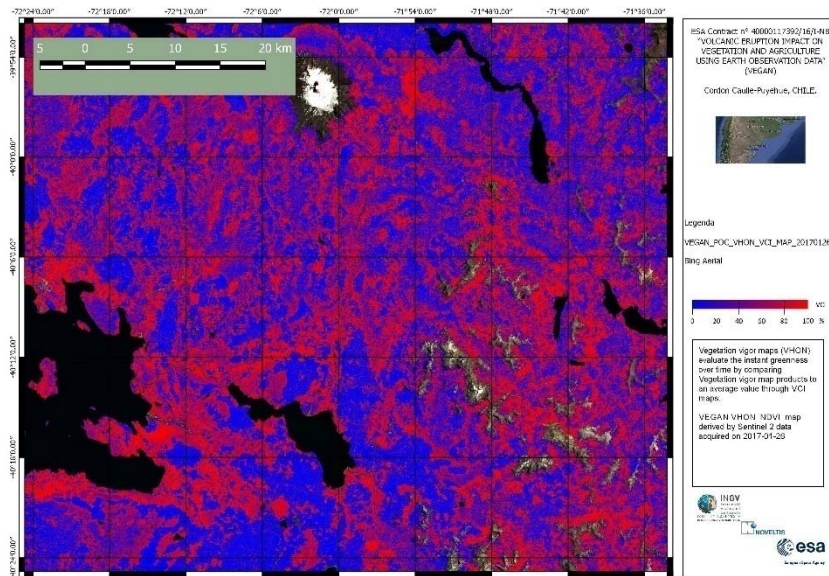
NDVI map, February 25<sup>th</sup> 2017



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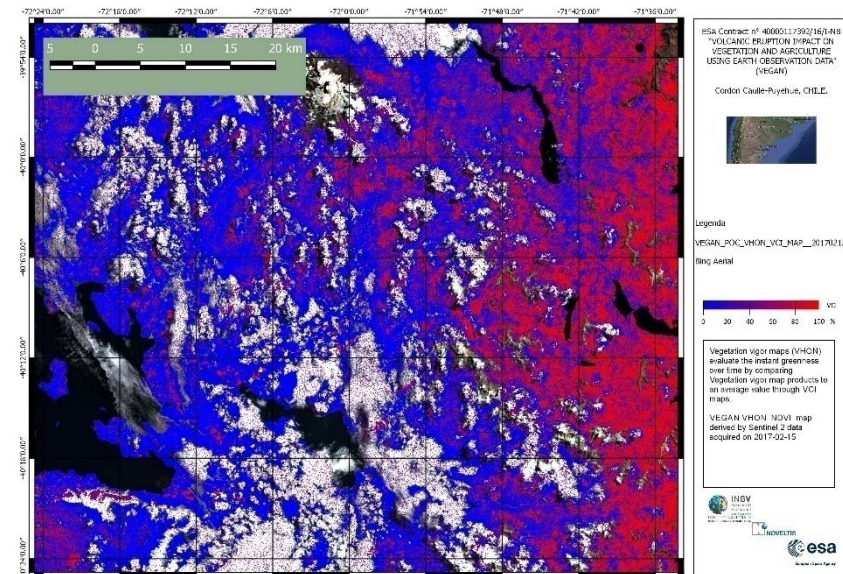
# Use case: Puyeu-Cordon Caulle

Generated Vegetation health monitoring products



VCI map, January 26<sup>th</sup> 2017

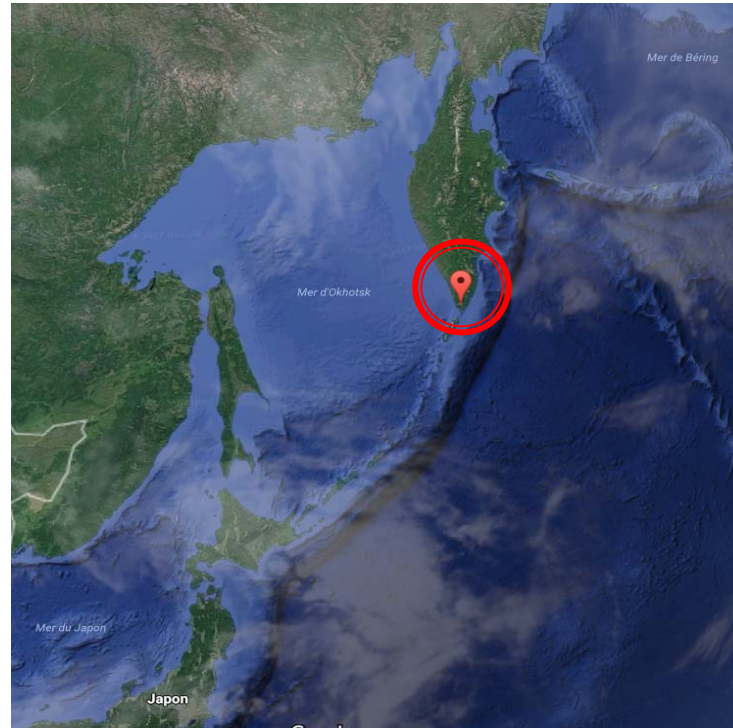
VCI map, February 25<sup>th</sup> 2017



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# Use case: Kambalny

▲ **Location:**



▲ **Studied event:** eruption of March 2017

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# Use case: Kambalny (blind test)

TIME TO DECIDE ERUPTIVE PARAMETERS: **30 min.**

Meteo data: Air Resource Laboratory, GDAS Global, from 25/03/2017 (00.00 UTC) to 28/03/2017 (21.00 UTC). Data every 3 h.

TIME TO DOWNLOAD AND TO PRE-PROCESS METEO DATA: **1 h**

TIME TO CODE MODIFICATIONS (una tantum): **3 h**

Simulation data:

- ash emission start 25/03/2017 h. 01.00 UTC
- ash emission end 28/03/2017 h. 21.00 UTC
- end of simulation 28/03/2017 h. 21.00 UTC
- calculation grid resolution  $0.5^\circ$
- calculation domain extent  $25/55^\circ$  lat,  $-150/+150^\circ$  long
- average particles density 2000 kg/m<sup>3</sup>
- shape factor 0.6
- MFR  $3.16 \times 10^5$  kg/s

**About 5 and ½ hour**

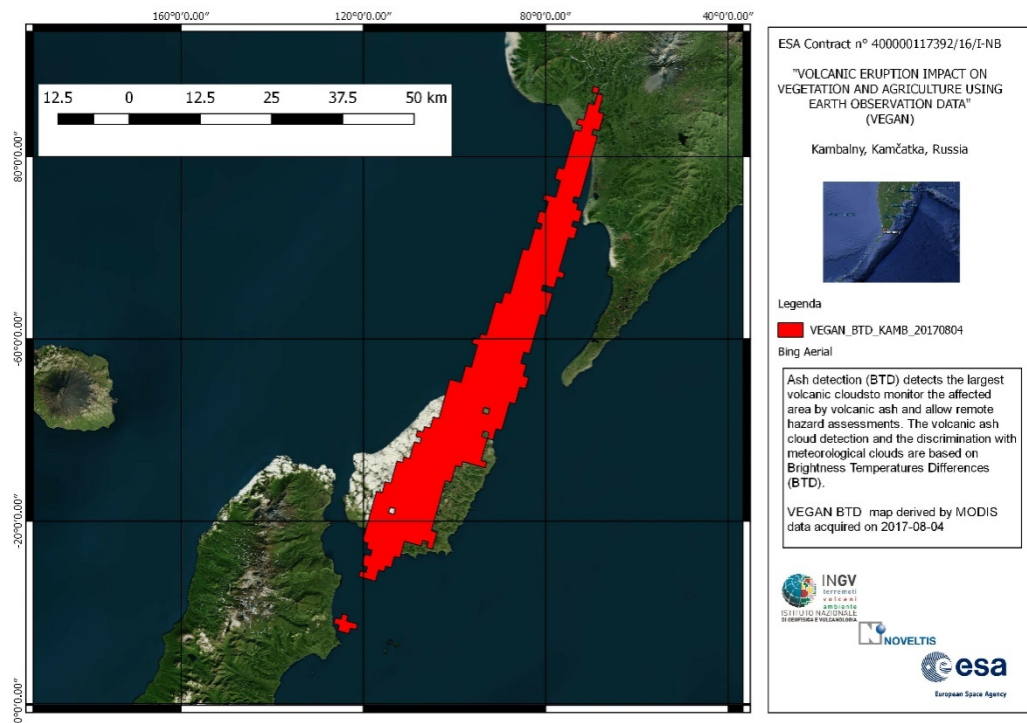
TOTAL TIME (SIMULATION AND POST-PROCESSING): **15 min**

TIME TO WRITE THE REPORT: **30 min**



# Use case: Kambalny

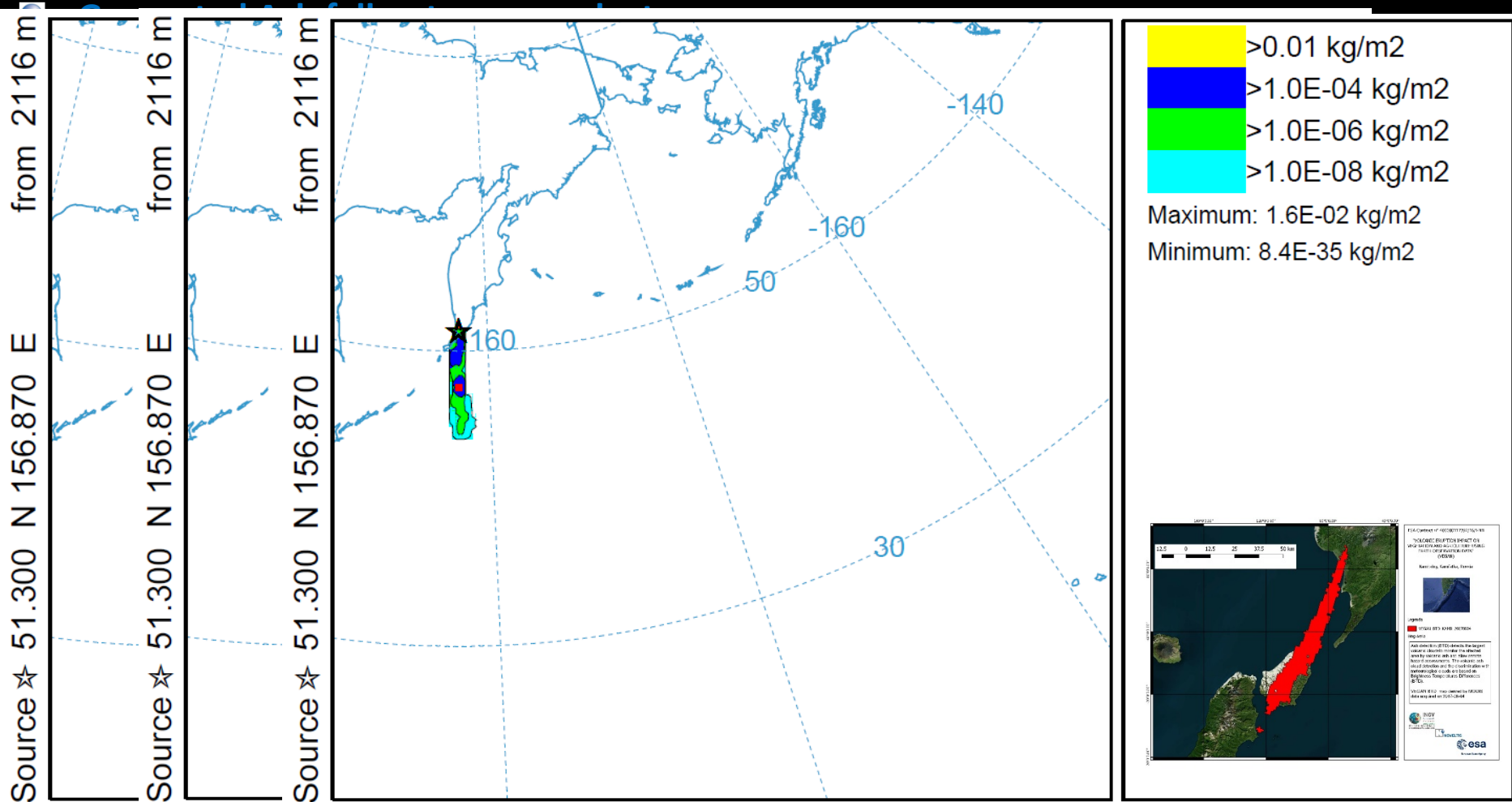
Generated Ash detection in the thermal infrared products



BTD map, April 8<sup>th</sup> 2017

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# Use case: Kambalny



GDAS METEOROLOGICAL DATA

# Use case: Kambalny

## Generated Hot spot map products



06/04/2017

26/04/2017

Hot spot maps, from February to April 2017

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# Costa Rica User community



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COSTA RICA

with local and national incidence and that transcend their work in the fields of teaching and social action. It is very important to note the UCR were not involved by the project beginning and its contribution have to be considered as kindly offered. Prof. Jorge Andres Diaz has been very kind and helpful in evaluating, both scientifically and technically, the products generated by the VEGAN project. We want to thank him for the commitment he has supported this project.

- ▲ Website: <https://www.ucr.ac.cr/>
- ▲ Manager of the UCR : : Dr. Henning Jensen Pennington
- ▲ Tel (+506) 2511-1250
- ▲ E-mail: [buzon.rectoria@ucr.ac.cr](mailto:buzon.rectoria@ucr.ac.cr)
- ▲ Sede "Rodrigo Facio Brenes" Montes de Oca, San José Costa Rica.



The Volcanological and Seismological Observatory of Costa Rica, is an interdisciplinary research institute of the National University. Its mission is seismic and volcanic monitoring to document, analyze and interpret these processes and disseminate the derived knowledge to contribute to the prevention of risks and mitigation of the disasters that these phenomena may generate

- ▲ Website: <http://www.ovsicori.una.ac.cr/>
- ▲ Manager of the OVSICORI : : Dott Montero Cascante Carlos
- ▲ Tel (506)2562 4001 (506)2261 0611 - (506)2261 0781
- ▲ E-mail: [ovsicori@una.cr](mailto:ovsicori@una.cr)
- ▲ Postal address 2386-3000 Heredia, Costa Rica.



The IMN (for its acronym in Spanish) is an institution affiliated to the Ministry of Environment and Energy (MINAE), is a scientific body that is in charge of the coordination of all meteorological and climatological activities in the country. It maintains a systematic monitoring of the weather to provide support for the safety of air navigation in the country, for the prevention of hydrometeorological disasters and contribute to the adverse effects of variability and climate change.

- ▲ Website: <https://www.imn.ac.cr/en/inicio>
- ▲ Manager of the IMN: -----
- ▲ Tel. T: (506)2222-5616 F: 2223-1837
- ▲ E-mail: -----
- ▲ Postal address San José, Costa Rica Barrio Aranjuez, Avenida 9 y Calle 17.

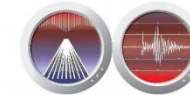
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# Use case: Turrialba

- ▲ **Involved end-users:** The University of Costa Rica  
The Volcanological and Seismological Observatory of Costa Rica  
The Instituto Meteorológico de Costa Rica



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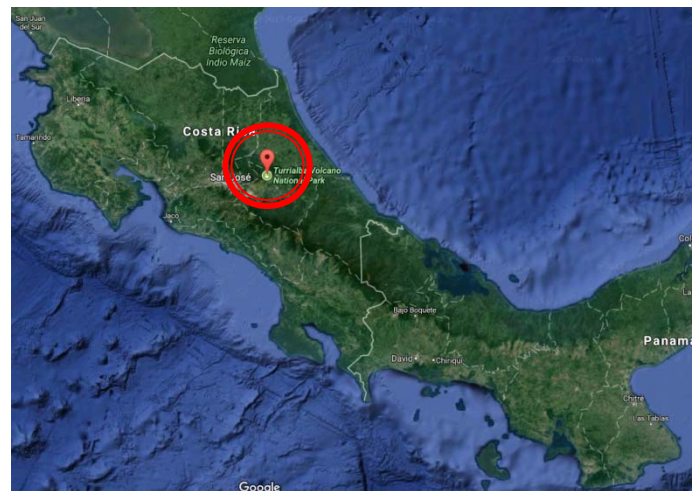


OVSICORI-UNA  
INSTITUTO DE INVESTIGACIÓN OBSERVATORIO  
VULCANOLÓGICO Y SISMOLÓGICO DE COSTA RICA



Instituto Meteorológico Nacional de Costa Rica

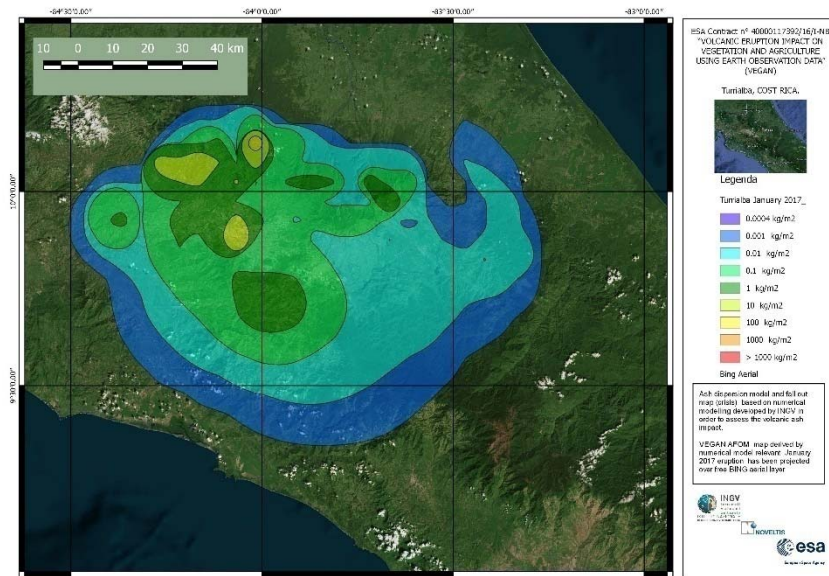
- ▲ **Location:**



- ▲ **Studied event:** eruptions of January and March 2017  
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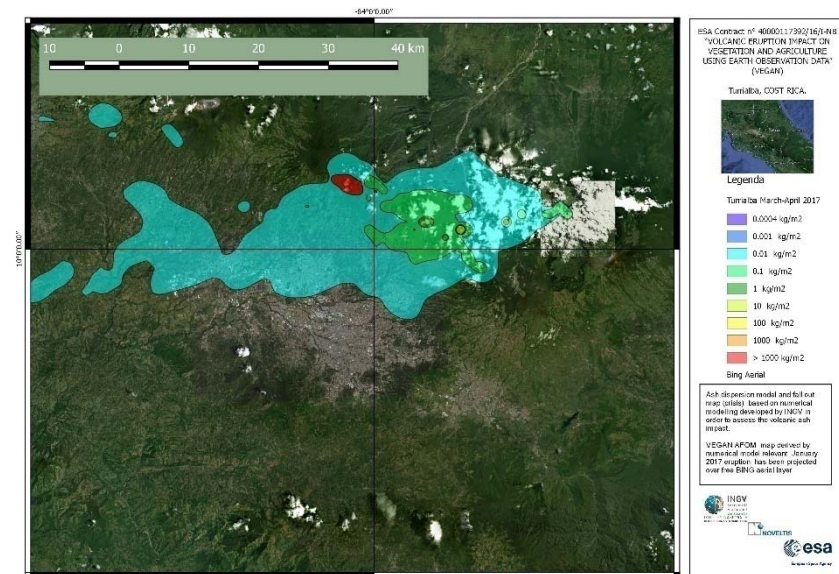
# Use case: Turrialba

## Generated Ash fall out map products



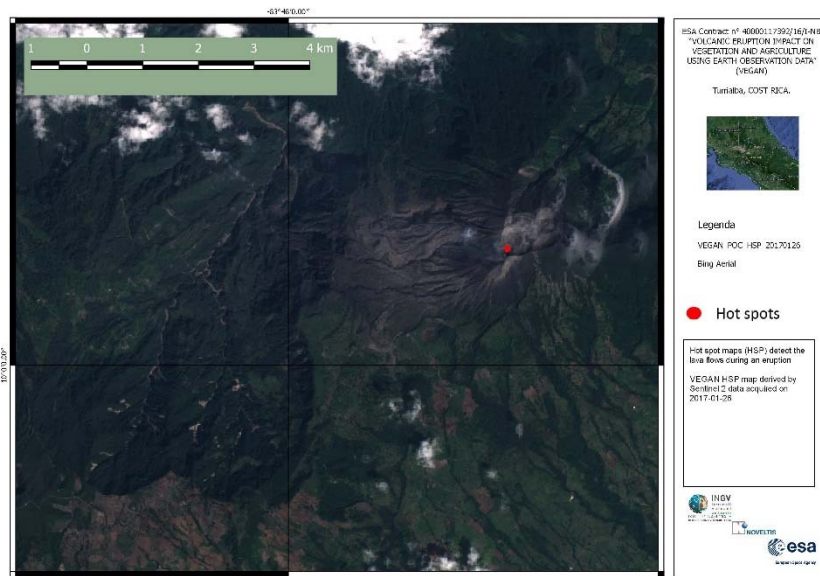
AFOM, January 2017

## AFOM, March/April 2017

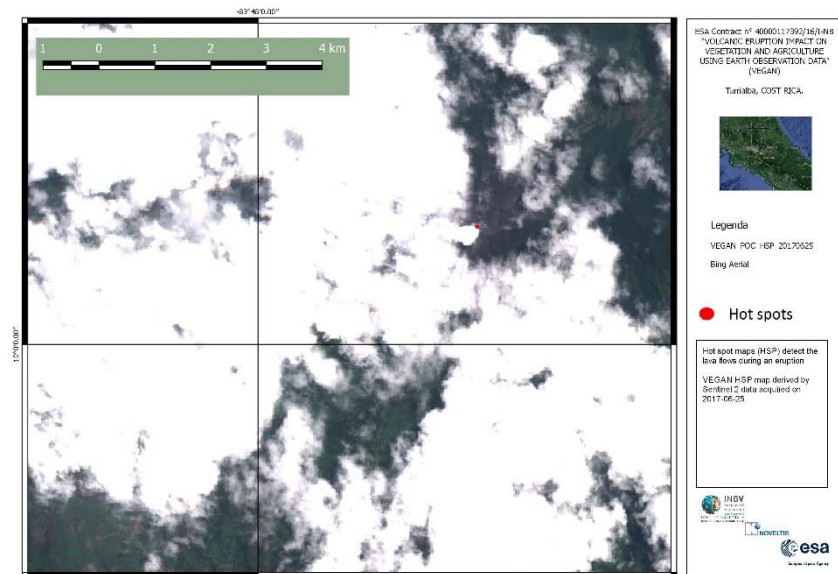


# Use case: Turrialba

Generated Hot spot map products



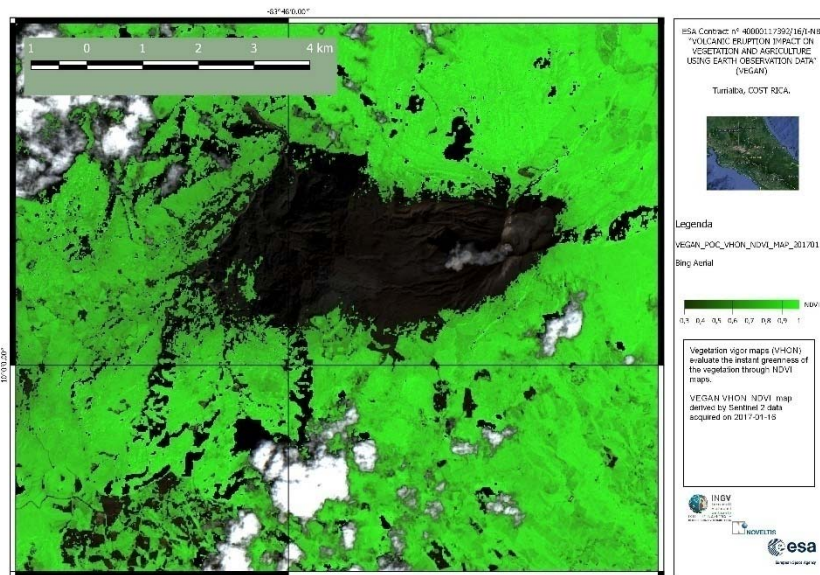
Hot spot map, June 25<sup>th</sup> 2017



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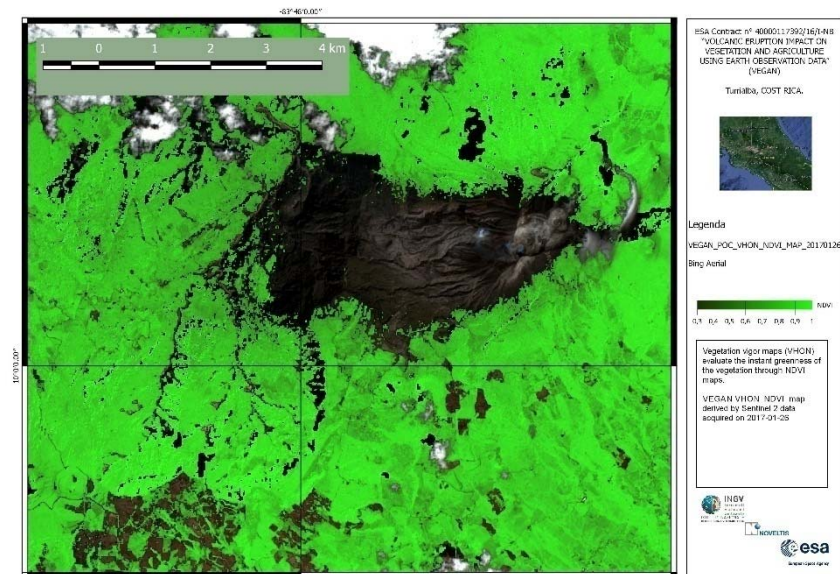
# Use case: Turrialba

Generated Vegetation vigor map products



NDVI map, January 16<sup>th</sup> 2017

NDVI map, January 26<sup>th</sup> 2017

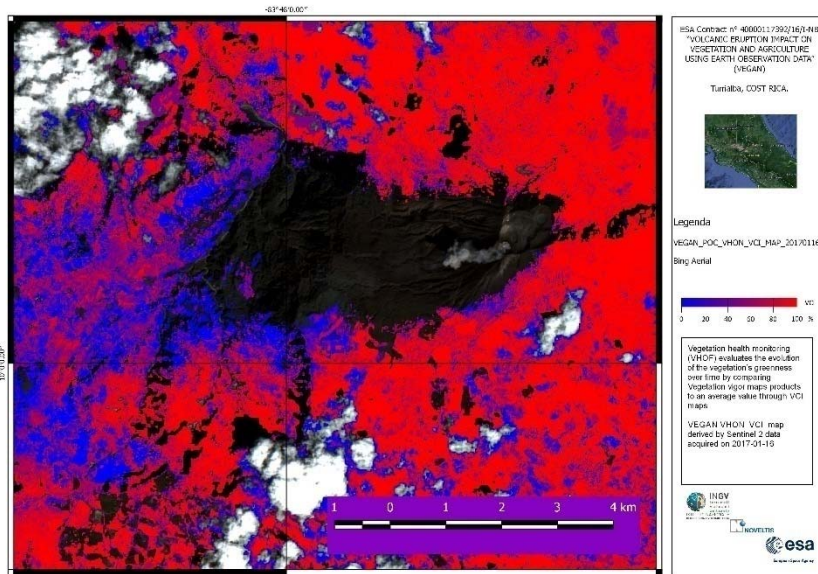


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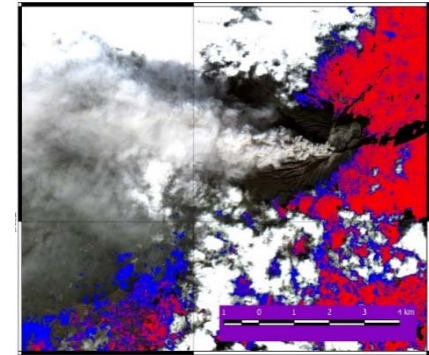
# Use case: Turrialba

Generated Vegetation health monitoring products

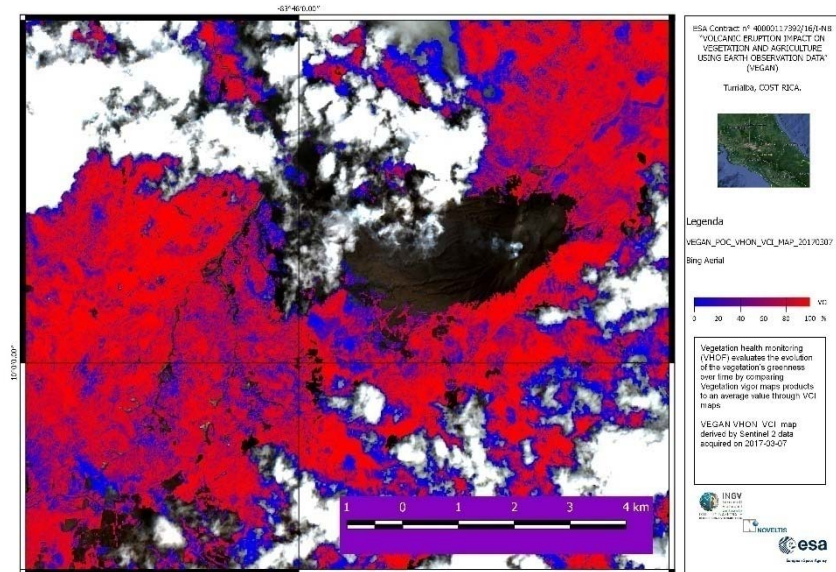


VCI map, January 16<sup>th</sup> 2017

Eruption of January 6<sup>th</sup> 2017



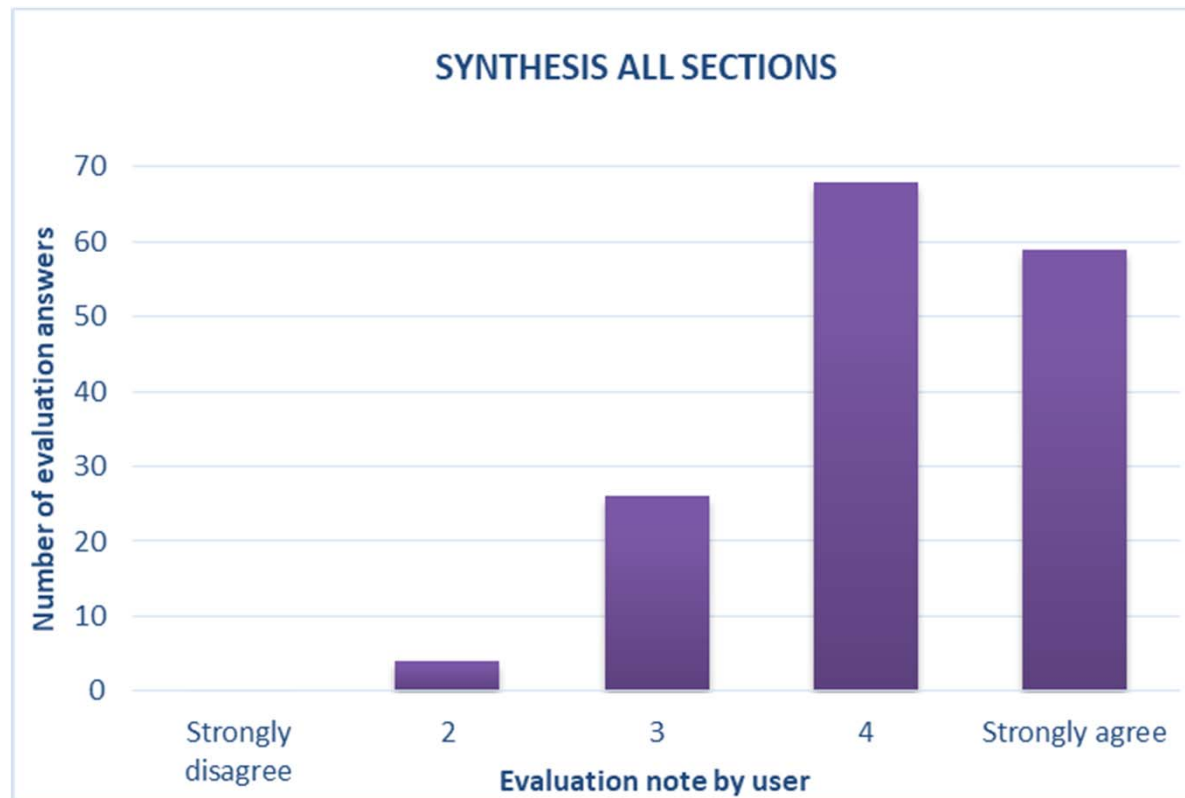
VCI map, March 7<sup>th</sup> 2017



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# General synthesis from user's perspective

Global satisfaction level



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# General synthesis from user's perspective

 General evaluation



Positive points	Points to be enhanced
Good utility at management level	Users would be more confident if VEGAN includes in-situ data in addition to satellite data
Good usability	Delivery frequency not fully sufficient for crisis products (limitation due to satellite data availability)
Easy-to-use	
It improves previous technologies already tried	
User friendliness	

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# General synthesis from producer's perspective

Product	Pre-crisis	Crisis	Post-crisis	Comments / Difficulties
Eruption detection	✓			Real-time capacity with SEVIRI data Some limitations concerning the real time with GOES data
Ash detection in the thermal infrared (TIR) spectral range	( ✓ )	✓		Some distortions with off-nadir acquisitions Negligible quantity of emitted ash are difficult to detect Presence of water vapour can mask the presence of ash
Ash dispersion model and fall out map		✓		Limitation of this procedure are due to the meteo data
Hot spot maps		( ✓ )	✓	Some limitations in case of clouds around the volcano
Vegetation vigor maps			✓	Some limitations in case of clouds around the volcano Sen2cor classification not correct for smoggy areas or opaque clouds Sen2cor vegetation classification removes vegetation pixel with very poor vigor
Vegetation health monitoring	✓		✓	Longer Sentinel-2 time series are required Biased in case of close eruptions over the same volcano Gas emissions cause also vegetation death

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# knowledgements

We would like to thank:

- **ESA** for the opportunity to contribute to the GEP and VEGAN project
- **NASA-JPL** for the very fruitful and long collaboration and for having continuously supported INGV by providing ASTER data to study and monitor Italian active volcanoes
- **USGS** for the active collaboration on LANDSAT8 data providing night time data and for the participation to the calibration activities on Italian Volcanoes.

THANK YOU



# Test Sites: Mt Etna, Sicily (Italy)

Mt Etna is the largest active volcano in Europe with a diameter of 40x40 kmq and elevation of about 3350 m a.s.l. Towering above the city of Catania on the island of Sicily, it has been growing for about 500,000 years. Mt Etna has the longest period of documented eruptions in the world. Etna is noted for the wide variety of eruption styles.



Country	Italy
Volcanic Region	Mediterranean and Western Asia
Primary Volcano Type	Stratovolcano(es)
Last Known Eruption	2016 CE
Latitude	37.734°N
Longitude	15.004°E
Summit Elevation	3330 m 10922 ft
Volcano Number	211060

A map of the island of Sicily, Italy, showing the location of Mount Etna. The map is labeled with 'Mappa' and 'Satellite' options. A red pin is placed on the eastern coast of Sicily, near the city of Catania, indicating the location of the volcano. Other cities labeled on the map include Palermo, Marsala, Messina, Siracusa, and the island of Lampedusa. The map also shows the surrounding sea and a zoom-in/out control.