F. Ferrucci and the EVOSS Team

Near-Real-Time Global Volcano Monitoring by Geostationary and Polar orbiting Payloads

REAI - Brussels 21/11/ 2013
EVOSS Design Concepts

On the technological and volcanological standpoint, EVOSS built on lessons learnt from the European Commission “Laboratory Volcanoes” initiative, funded in FP5, and from the ESA’s DUP (Data User Programme, 1998-2002) and DUE (Data User Element, 2003-2007).

EVOSS is:
B) Designed to serve in **Supra-Regional operations theatres**
C) **Very-high Temporal Resolution and Real-Time are given priority** over high-to-very high spatial resolution at moderate-to-low refreshment rates
D) **System(s) scaled on spatially scattered, long lasting crises** (months to years);
E) **Sustainability of data provision has priority.**
Technology: a ‘cloud’ of remote processors runs - 24/7 and in real-time - State-of-Art algorithms relating to processing methods that have proved both robust, and suited to unsupervised RT operations.

Structure: in the ‘cloud’, each product has 1 RT/NRT content provider (6 content providers in 4 countries, 1 central dynamic repository serving the Virtual Volcano Observatory, and 1 supervision and quality control unit).

Demo/Ops.: From October 9, 2011 to June 30, 2013 (full – for EC grant)
From July 12, 2013, for Thermal and SO2 GOME-2

Success: 94% ➔ 45 out of 48 eruptions (45 subaerial and 3 submarine) by any combination of methods - excepting ground deformation.

Access: Full real-time access to the VVO from December 2011 onwards.

Improvements: upon request of End Users, or based on new evidence from research, or to exploit new observation modes.

migrations: RSS on MSG-1 and -2, and MSG-2 and -3, full disk porting tests: JAMI / MTSAT-1 and -2 ➔ 2012-2013 Tolbachik
Hi-Temp detection and estimate of radiant and mass fluxes

SO₂ mass and mass flux

12-06-11 21:15

VVO

Change Detection, Pattern recognition, Volume Change

Eruptive clouds
<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nyamulagira (Congo)</td>
<td>Eruption</td>
<td>January 2 to 29, 2010</td>
</tr>
<tr>
<td>Soufriere Hills (Montserrat)</td>
<td>Pyroclastic flow on</td>
<td>February 11, 2010</td>
</tr>
<tr>
<td>Eyjafjallajökull (Iceland)</td>
<td>Eruption</td>
<td>March 20, 2010</td>
</tr>
<tr>
<td>Manda Hararo (Ethiopia)</td>
<td>Eruption</td>
<td>March 21, 2010</td>
</tr>
<tr>
<td>Piton de la Fournaise (Reunion)</td>
<td>Eruption</td>
<td>October 14, 2010</td>
</tr>
<tr>
<td>Etna (Italy)</td>
<td>Eruptions on:</td>
<td>January 12, 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>« April 9 and May 11, 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May 24, 2011</td>
</tr>
<tr>
<td>Grimsvötn (Iceland)</td>
<td>Eruption</td>
<td>May 24, 2011</td>
</tr>
<tr>
<td>Nabro (Eritrea)</td>
<td>Eruption</td>
<td>June 12 to July 17, 2011 (first tests)</td>
</tr>
<tr>
<td>Nyiragongo (Congo)</td>
<td>Lava lake - permanent</td>
<td>since June 2011 (SEVIRI operation tests)</td>
</tr>
<tr>
<td>Erta Ale</td>
<td>Lava lake – permanent</td>
<td>June 2011 to June 2013 (MODIS ops.demo)</td>
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<tr>
<td></td>
<td></td>
<td>« August 5–12–20–29, 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Quantitative Thermal and SO2 online</td>
</tr>
<tr>
<td>Nyamulagira (Congo)</td>
<td>Eruption</td>
<td>November 6, 2011 to March 15, 2012</td>
</tr>
<tr>
<td>Etna (Italy)</td>
<td>Eruptions on:</td>
<td>November 15, 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>« January 3, 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>« February 6, 2012</td>
</tr>
<tr>
<td>Stromboli (Italy)</td>
<td>Eruption</td>
<td>July 6-7, 2012</td>
</tr>
<tr>
<td>Etna (Italy)</td>
<td>Eruptions on:</td>
<td>March 4-18, 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>« April 1-12-24, 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>« March 4, 16; April 3, 11, 18, 20 and 27, 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Quantitative Thermal and SO2 online</td>
</tr>
<tr>
<td>Jebel Zubair (Yemen)</td>
<td>Submarine</td>
<td>September 29 – October 14, 2013</td>
</tr>
<tr>
<td>Etna (Italy)</td>
<td>Eruptions on:</td>
<td>October 26-27, November 11 an 16-17, 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Quantitative Ash Retrieval online</td>
</tr>
</tbody>
</table>
INTEGRATED THERMAL – SO₂ SERVICE

Congo:
18-month SO₂ monitoring
(including the eruption of Nyamulagira, Jan. 2010)

Nabro:
merge of synchronous Thermal Radiant flux and SO₂ DU_{max} values
Eruptions
Mt. Etna – April 24th, 2012

Anomaly Notification

Service - High Rate Hot Spot (MSG Seviri)

Cloud Coverage [%]

Radiant Flux [GW]

24 Apr 2012 02:00

Cloud Coverage: 35%

Radiant Flux: 29.66 GW
INTEGRATED THERMAL - ASH SERVICE

Thermal Anomalies Service - High Rate Hot Spot (MSG Seviri) - Radiant Flux over Etna (Italy)

Product Information
- Date: 2012/04/01 03:57
- Total Radiant Flux: 16.18 GW
- Cloud Coverage: 23%

Click over the product preview to enlarge it.
DEM Validation – Piton de la Fournaise

Piton de La Fournaise
IGN-SHOM 2008 survey, \( \lambda = 1.06 \mu m, 5-10 \) pt/m²

Precision in height ~20 cm, Resolution = 1 m

\( \Delta (CSK_{2011} - \text{LiDAR}_{2008}) \)

Subtraction of resampled EVOSS’ SqueeSAR™ DEM from the 1m LiDAR DEM of the area, returns shape and volume of the small, October 2010 lava flow
Evolution of the Nyiamulagira lava flow in 2011
Nyamuragira 2011–2012 morphology change

CSK Himage – December 9, 2011
Nyamuragira crater dynamics

May 12, 2012

May 14, 2012
Nyamuragira 2012 - IR vs. SAR

TIR Landsat 7 (LSC-off) 20111121 + CSK lava flow on 20111120 by SqueeSAR™ constrained $\Delta_{\text{DEM}}$
Mt. Etna - Mar 18, 2012 (MSG-2 + RSS MSG-1)

Mt. Etna - Apr 12, 2013 (MSG-3 + RSS MSG-2)
JAMI/MTSAT-1
JAMI/MTSAT-2

○ JAMI (MTSAT-1 & -2, hourly → pixel ≈ 50 km²) vs. ♦ MODIS (Terra & Aqua, 4 daily → 1 km²)

MEASURED Onset: 14:30 of 20121128 (≈20h before earliest notifications)

Radiant flux (10^9 W)

Acquisition date

JAMI full Disk
(pixel size from 16 km² at nadir to ca. 50 km² over the eruption area)

Tolbachik (Kamchatka) 2012-2013
The EC project started on March 1, 2010, held the KO meeting on April 15, 2010, formally finished on July 11, 2013. The system is still running in its more sustainable and robust component.

The development was faster than expected - almost all methods proved more robust than expected. This allowed EVOSS going operational between To+16 and +22, instead of To+24 and beyond.

The system proved extremely reliable, as the percentage of failure (non-operational time) keeps steadily under 1%, despite the wide areal distribution of product makers and the huge Region of Interest.

In consideration of the system’s reliability and the controlled cost of multidisciplinary unsupervised operations, upon request of major stakeholders (the Government of Djibouti, the Observatory of Goma, the Observatory of Karthala, the Geological Survey of Tanzania) and with the agreement of relevant EC entities, the system was kept running beyond its formal expiry because it is exploited and is – at least partly – sustainable.
2010 – 2013....

....and more