A spectra classification methodology of infrared hyperspectral images to reach near real-time SO₂ emission flux estimation of Mount Etna plume

Charlotte Segonne ¹, Nathalie Huret ¹, Sébastien Payan ², Mathieu Gouhier ³

¹ LaMP, OPGC, Université Clermont Auvergne, Clermont Ferrand, France

² LATMOS, Sorbonne Université, Paris, France

³ LMV, OPGC, Université Clermont Auvergne, Clermont Ferrand, France

Study context

IMAGETNA Campaign 21-26 June 2015 at Mount Etna during quiescent state of activity

In collaboration with:
LPC2E (Orléans, FR)
LATMOS (Paris, FR),
INGV (Italie),
ONERA (Palaiseau, FR),
LOA (Lille, FR)

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Deployment of the HyperCam LWIR (Telops Co.)

→ **Hyperspectral Imager** in TIR

$[7.7 - 11.8] \mu\text{m}$ (i.e. $[850 - 1300] \text{cm}^{-1}$)

Max spectral resolution 0.5 cm^{-1}

320×256 pixels ; FOV: $6.4 \times 5.1^\circ$

3D images

Objectives

**Optimal
retrieval**

SO₂ Slant column densities (ppm.m)

**Emission fluxes
of SO₂**

Optimal retrieval of slant column densities

Radiative transfert model + Minimization algorithm (Levenberg-Marquardt type)

→ LARA (LATMOS Atmospheric Retrieval Algorithm)¹

Parameterization validated
→ Robust model

Results – Pixel-by-pixel retrieval

SO₂ Slant column densities ppm.m
(26/06/2015 – 08:27 UTC)

- Retrieval of 1 image = 7 days of calculation on Ciclad (IPSL computers) for SO₂ micro-window
- Very good quality of retrieval with reduced $\chi^2 \leq 5$

Dataset from IMAGETNA campaign:

- 6 200 images
- 116 millions of pixels

➔ 110 years of calculation!

Development of a methodology for fast and massive retrieval of the images

*Published in: Huret et al. - Remote Sensing 2019, 11, 1175
doi:10.3390/rs11101175*

Images massive retrieval: creation of a neural network

Band 1: 1000-1100 cm^{-1} Band 2: 1100-1200 cm^{-1}

I_{O_3} integral BT

I_{SO_2} mean BT

- Training dataset:
 - 5 images with SO_2 SCD retrieved pixel-by-pixel
- Tested dataset:
 - ~ 900 images from sequences with similar geometry and weather conditions.

Library containing 195 classes

Massive retrieval : results

- Tested dataset pixels classified and images of SO₂ SCD retrieved using the library.
- ~ 15% of missing classes in the library (pixels in blue) mostly in dense plume part.

Examples of retrieved images:

1 image processed in ~40 seconds !

For more information

- **Huret, N. et al.,** *Infrared Hyperspectral and Ultraviolet Remote Measurements of Volcanic Gas Plume at MT Etna during IMAGETNA Campaign.* Remote Sensing **2019**, 11, 1175 (<https://doi.org/10.3390/rs11101175>)
- **Segonne, C. et al.,** *A Spectra Classification Methodology of Hyperspectral Infrared Images for Near Real-Time Estimation of the SO2 Emission Flux from Mount Etna with LARA Radiative Transfer Retrieval Model.* Remote Sensing **2020**, 12(24), 4107 (<https://doi.org/10.3390/rs12244107>)

Contact

charlotte.segonne@uca.fr