



HAL
open science

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

Charlotte Segonne, Nathalie Huret, Sébastien Payan, Mathieu Gouhier

► To cite this version:

Charlotte Segonne, Nathalie Huret, Sébastien Payan, Mathieu Gouhier. A spectra classification methodology of infrared hyperspectral images to reach near real-time SO₂ emission flux estimation of Mount Etna plume. EGU General Assembly 2021, Apr 2021, Online, Unknown Region. pp. EGU21-15239, 10.5194/egusphere-egu21-15239 . insu-03183348

HAL Id: insu-03183348

<https://insu.hal.science/insu-03183348>

Submitted on 1 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

Charlotte Segonne¹, Nathalie Huret¹, Sébastien Payan², Mathieu Gouhier³

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

² LATMOS, Sorbonne Université, Paris, France

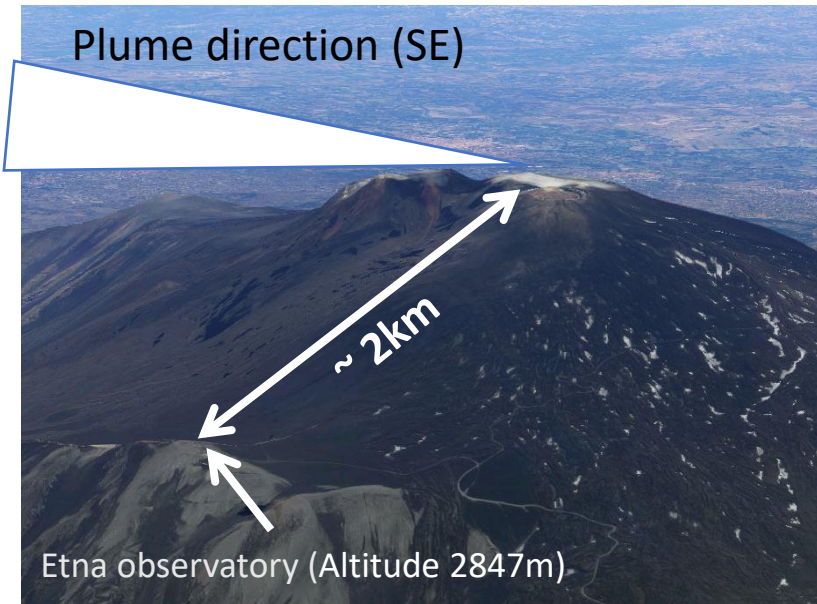
³ LMV, OPGC, Université Clermont Auvergne, Clermont Ferrand, France

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)



© Google Maps



Deployment of the HyperCam LWIR (Telops Co.)

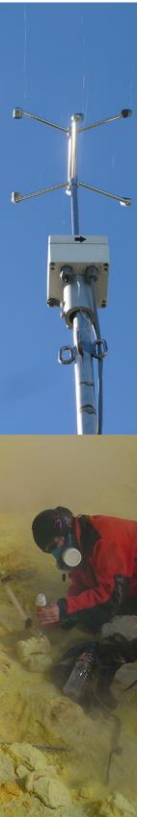
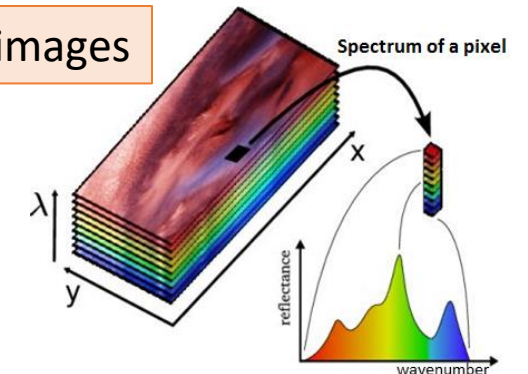
→ **Hyperspectral Imager** in TIR

[7.7 – 11.8] μm (i.e. [850 – 1300] cm^{-1})

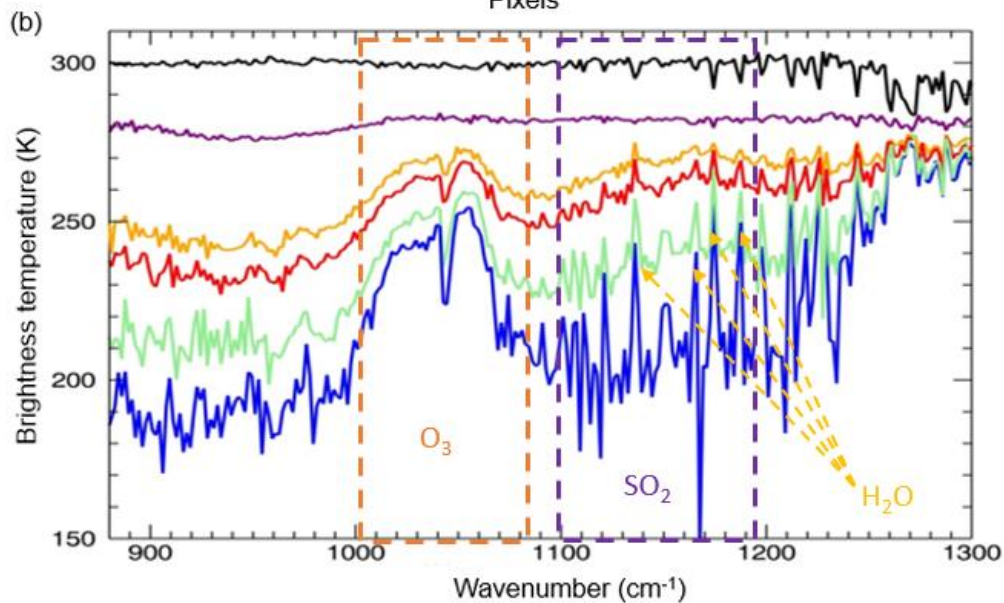
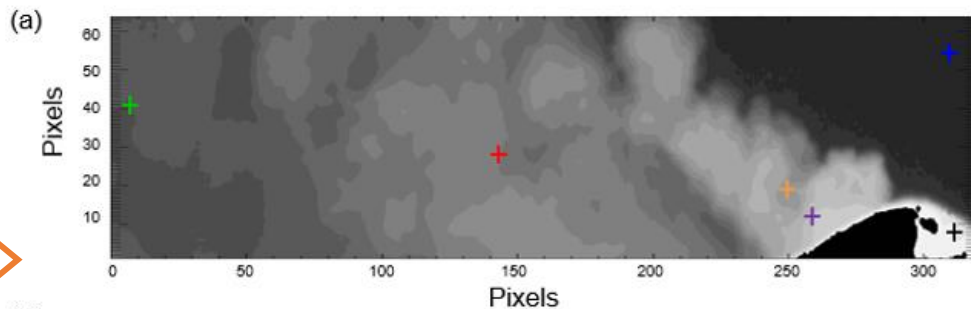
Max spectral resolution 0.5 cm^{-1}

320 x 256 pixels ; FOV: 6.4 × 5.1°

3D images

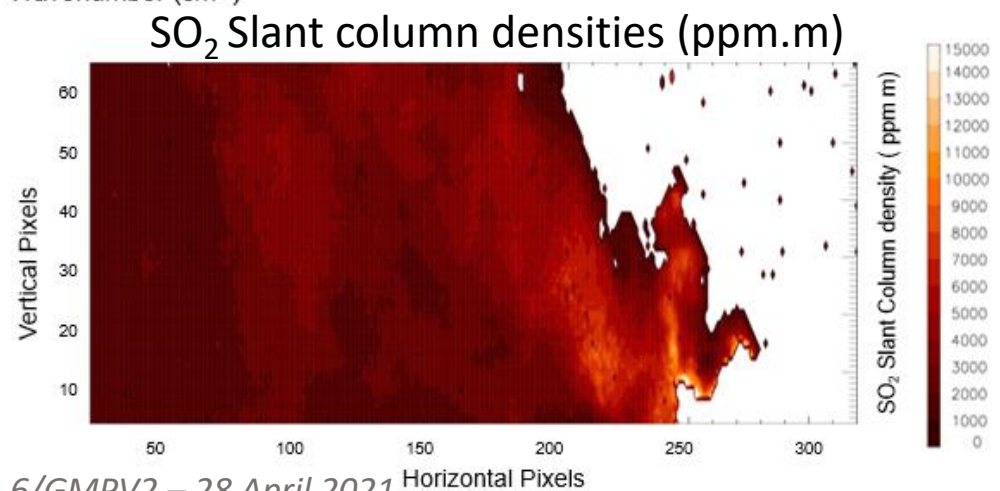


Objectives



Optimal retrieval

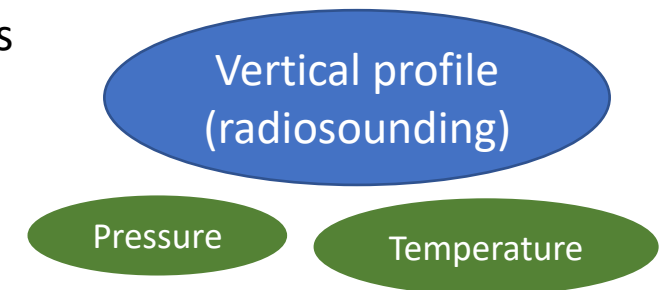
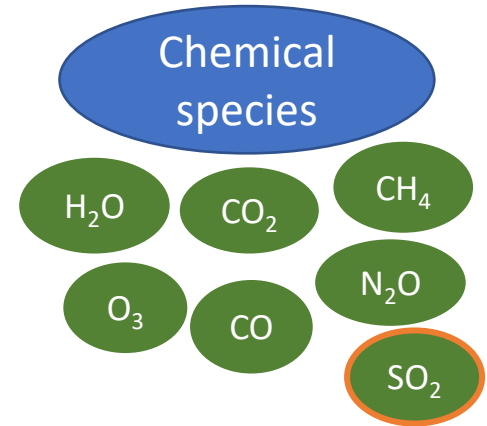
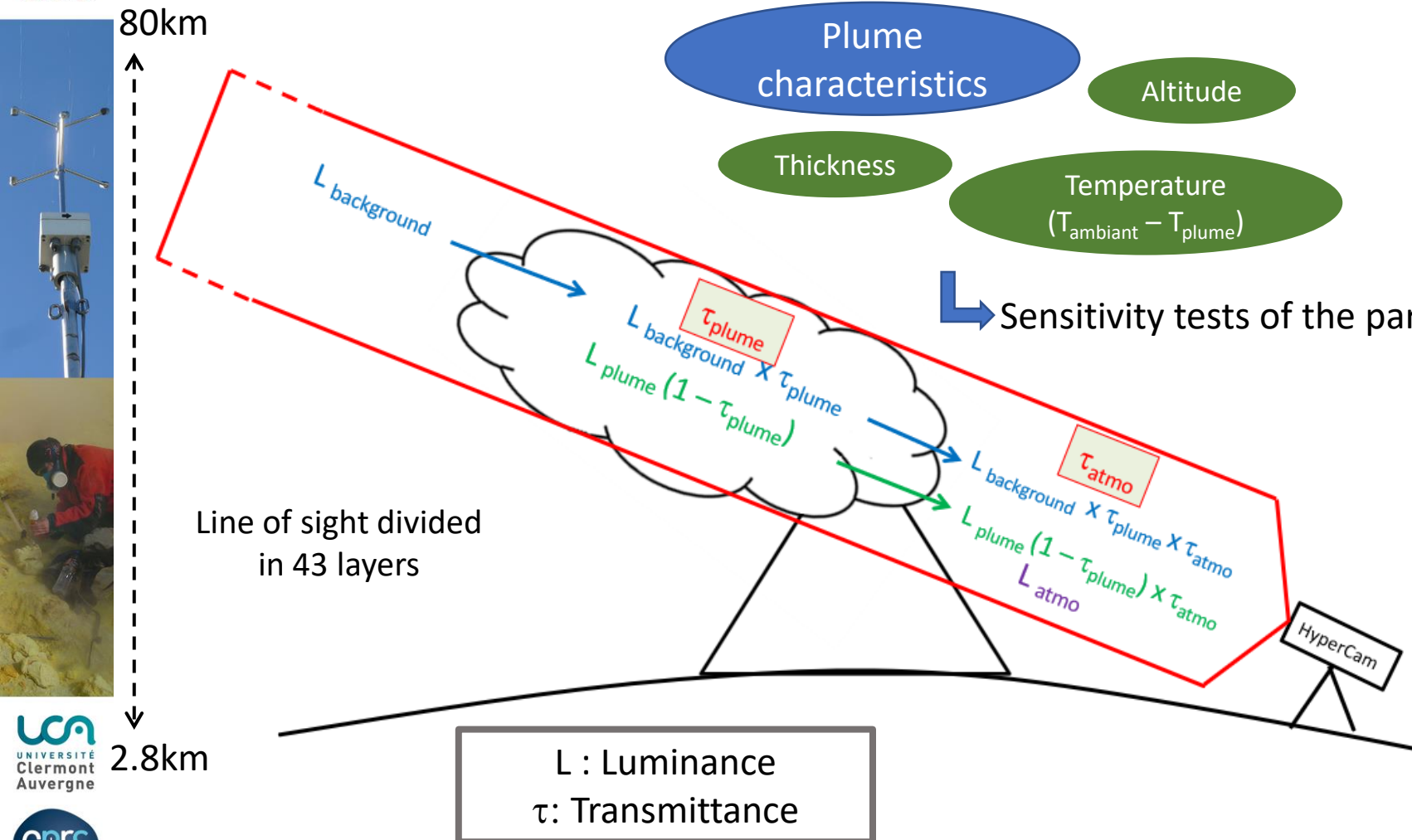
Emission fluxes of SO₂



Optimal retrieval of slant column densities

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

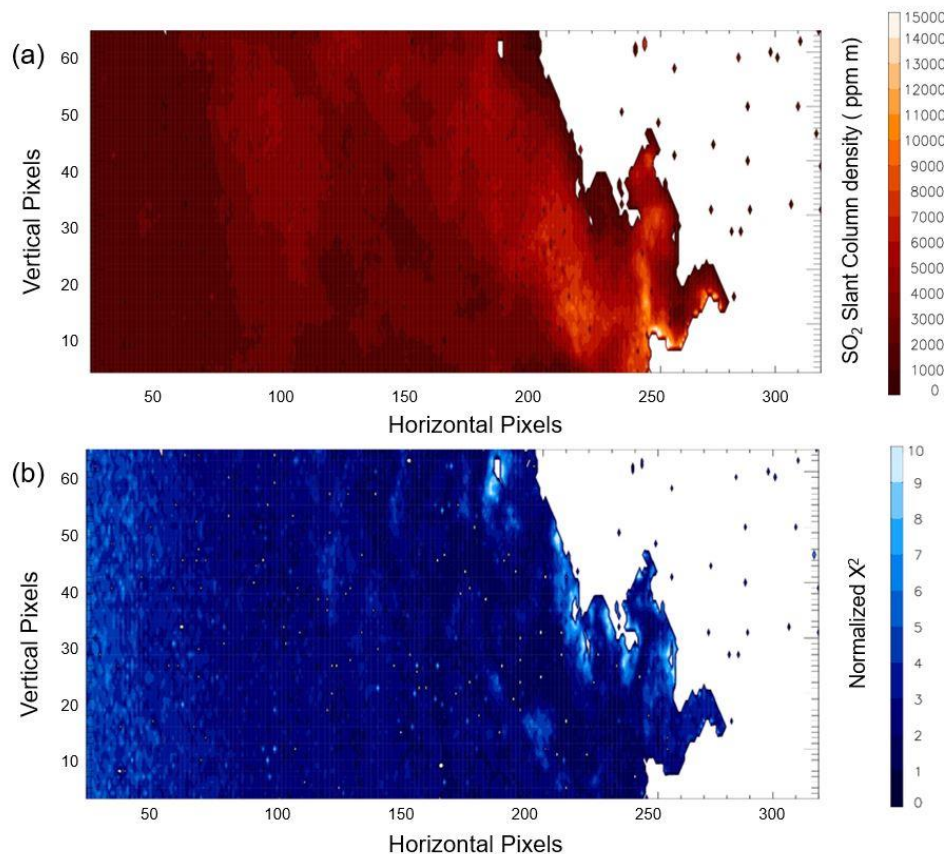
→ LARA (LATMOS Atmospheric Retrieval Algorithm)¹



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

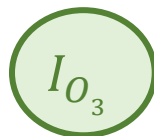


*Published in: Huret et al. - Remote Sensing 2019, 11, 1175
 doi:10.3390/rs11101175*

Images massive retrieval: creation of a neural network

Neural network
2 layers = 2 spectral information

Training dataset
5 images = 102400 pixels

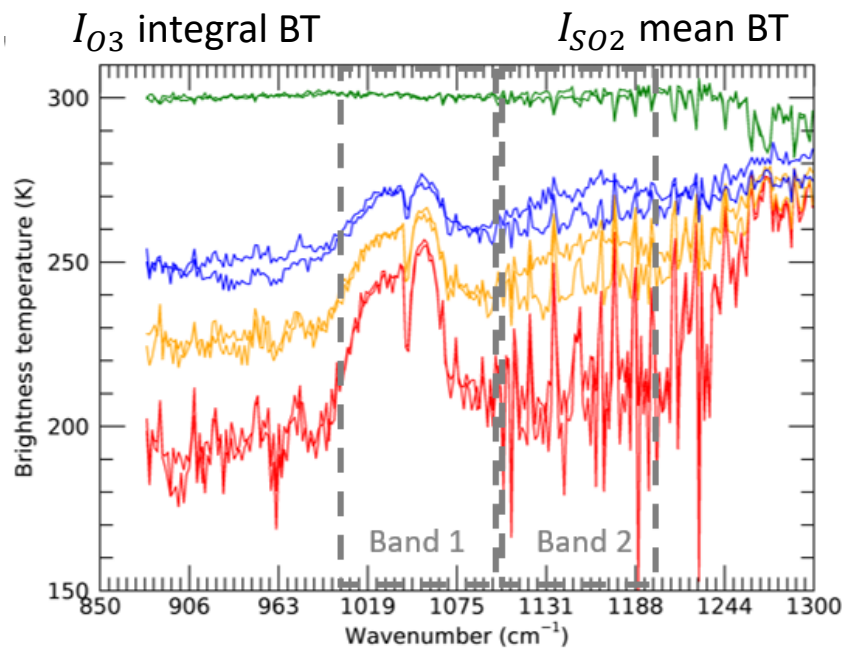


SO₂ SCD
(ppm.m)

Library
 $SO_2 = f(I_{O_3}, I_{SO_2})$

Band 1: Atmosphere opacity
Band 2: SO₂ concentration

Band 1: 1000-1100 cm⁻¹ Band 2: 1100-1200 cm⁻¹



- Training dataset:
 - 5 images with SO₂ SCD retrieved pixel-by-pixel
- Tested dataset:
 - ~ 900 images from sequences with similar geometry and weather conditions.

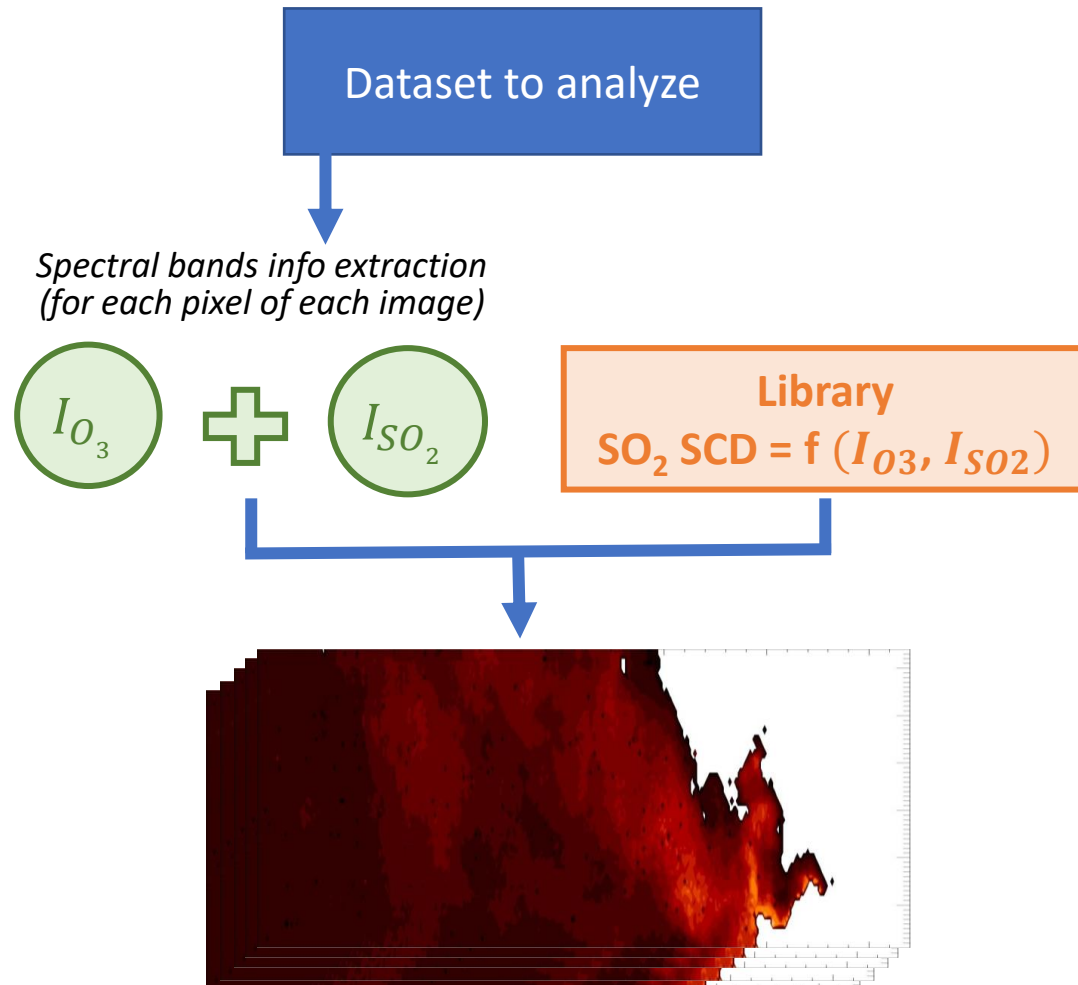
Library containing 195 classes



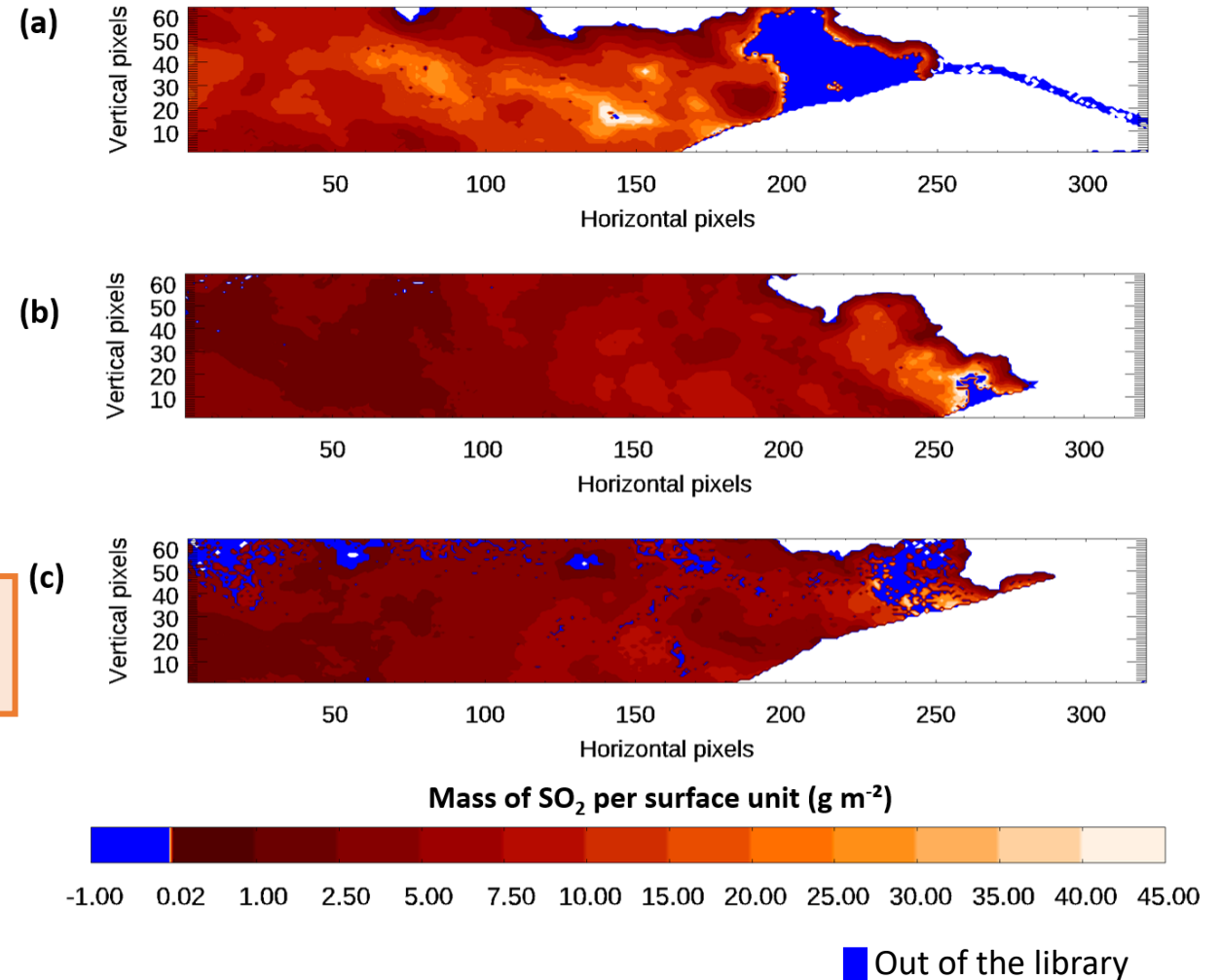


Massive retrieval : results

- 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

