

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

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

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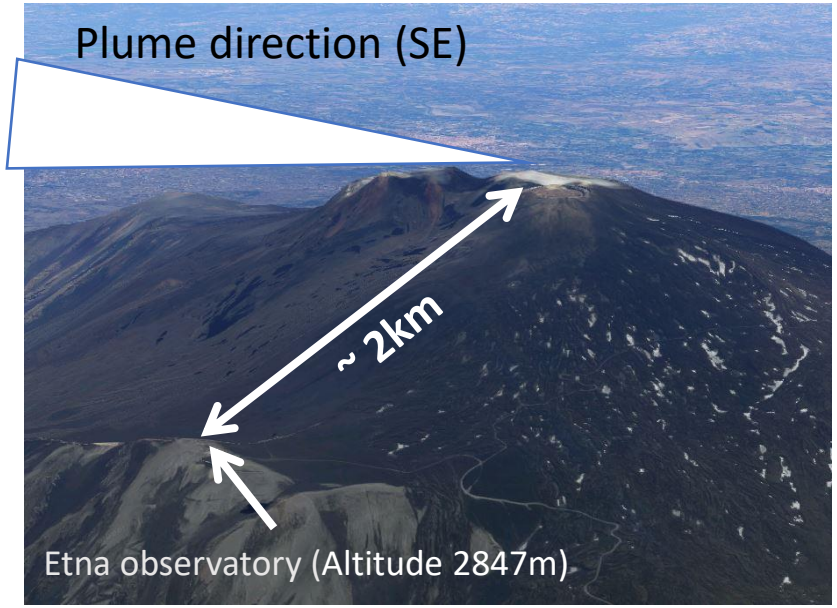
[2] LATMOS, Sorbonne Université, Paris, France

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

vEGU 2021 – #15239 – PICO session ITS3.6/GMPV2 – 28 April 2021

Study context

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



© Google Maps

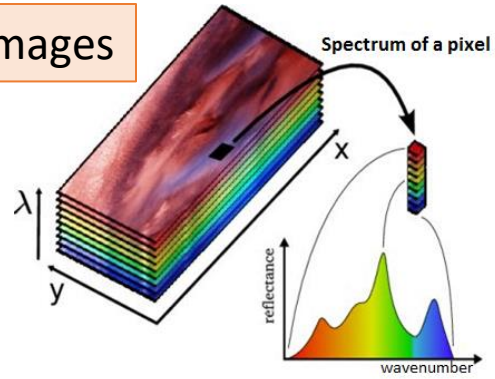


In collaboration with:
LPC2E (Orléans, FR)
LATMOS (Paris , FR),
INGV (Italie),
ONERA (Palaiseau , FR),
LOA (Lille , FR)



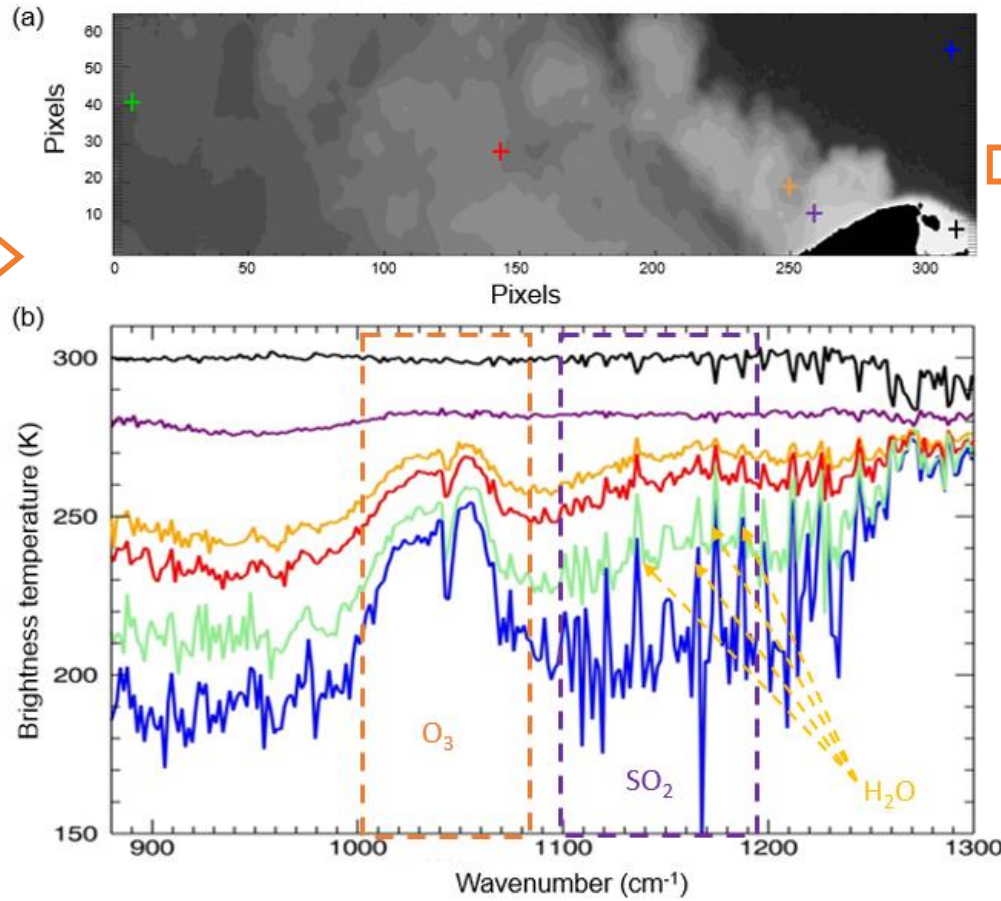
Deployment of the HyperCam LWIR (Telops Co.)
→**Hyperspectral Imager** in TIR
[7.7 – 11.8] µm (i.e. [850 – 1300] cm^{-1})
Max spectral resolution 0.5 cm^{-1}
320 x 256 pixels ; FOV: 6.4 × 5.1°

3D images



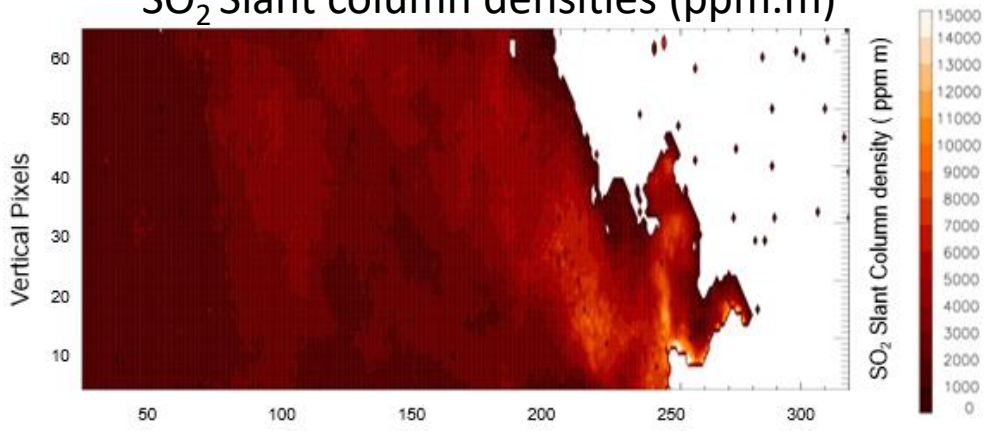
Objectives





Optimal retrieval

SO_2 Slant column densities (ppm.m)



Emission fluxes of SO_2

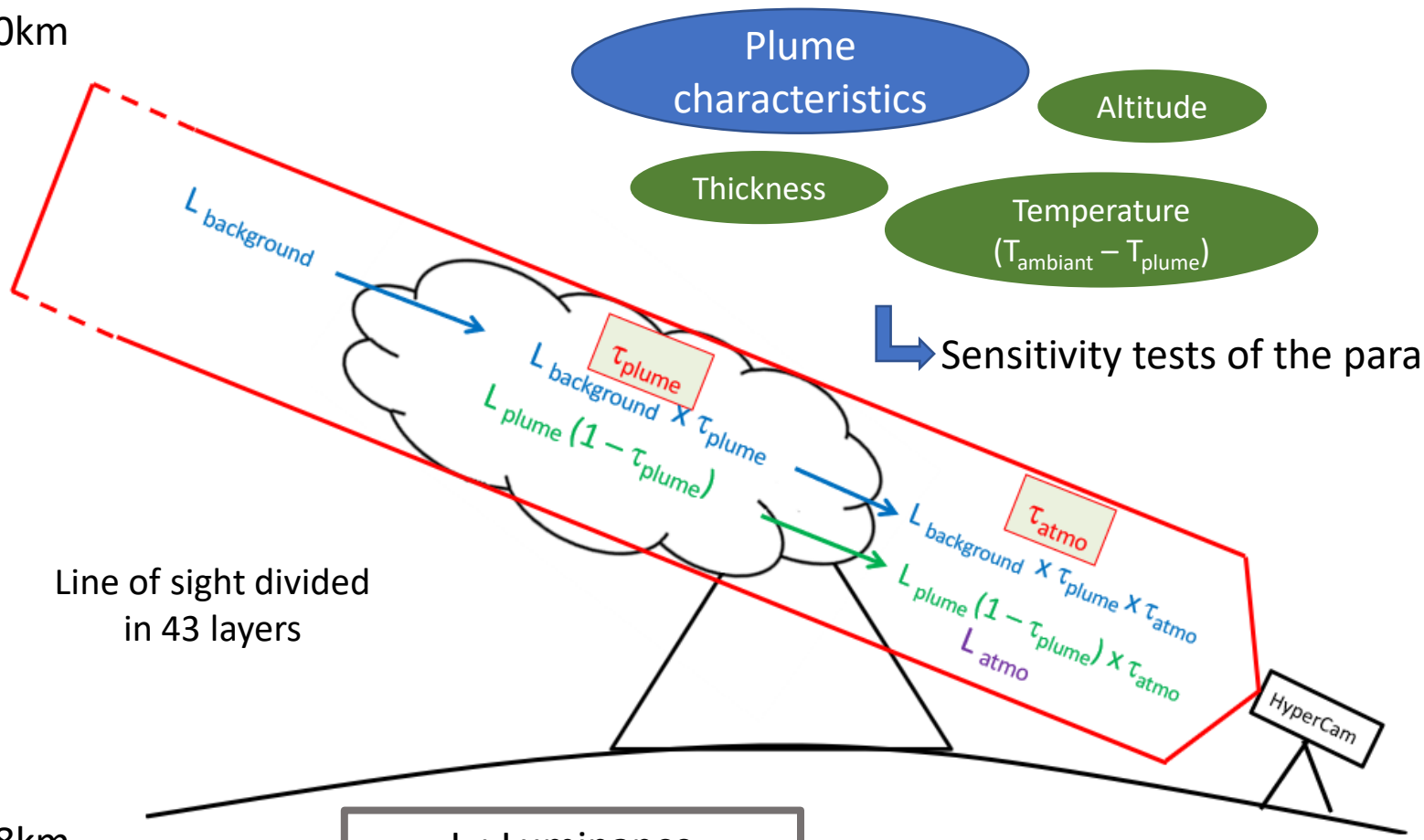
Optimal retrieval of slant column densities

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

→ LARA (LATMOS Atmospheric Retrieval Algorithm)[1]





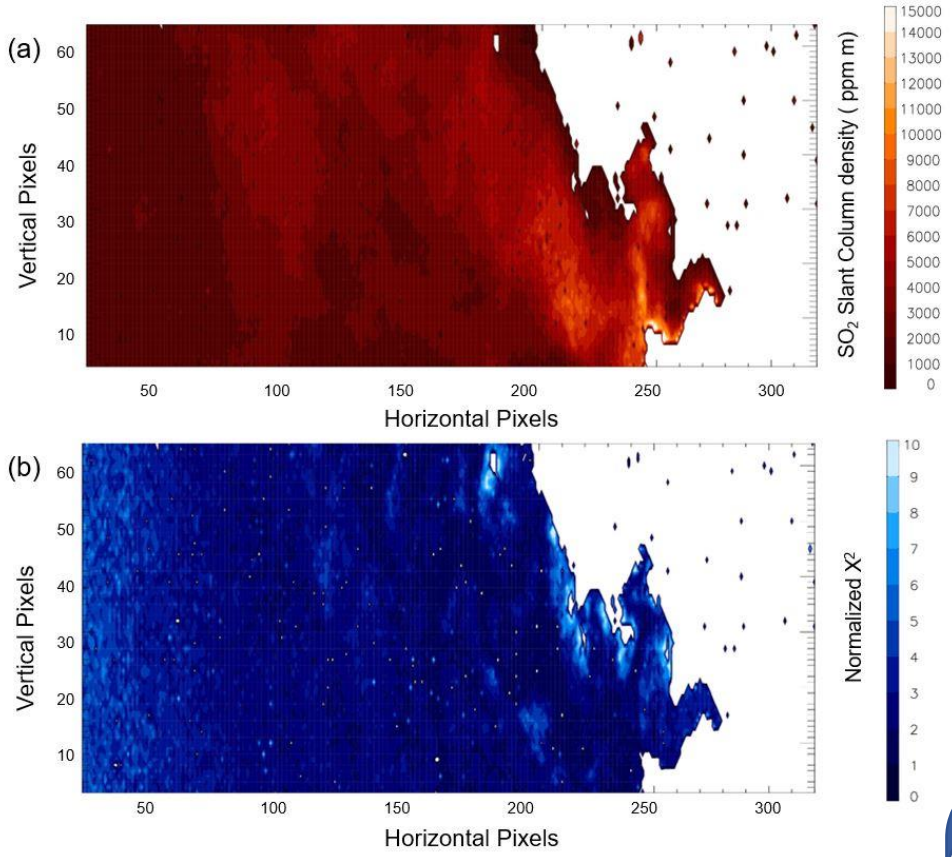


Parameterization validated
→ Robust model

[1] Payan et al. 1998, 2010

Results – Pixel-by-pixel retrieval

SO_2 Slant column densities ppm.m
(26/06/2015 – 08:27 UTC)



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

- **Retrieval of 1 image = 7 days of calculation** on Ciclad (IPSL computers) for SO_2 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

Images massive retrieval: creation of a neural network

Neural network
2 layers = 2 spectral information

Training dataset
5 images = 102400 pixels

→ I_{O_3} + I_{SO_2} →

Band 1:
Atmosphere opacity

Band 2:
SO_2 concentration

SO_2 SCD
(ppm.m)

⟹

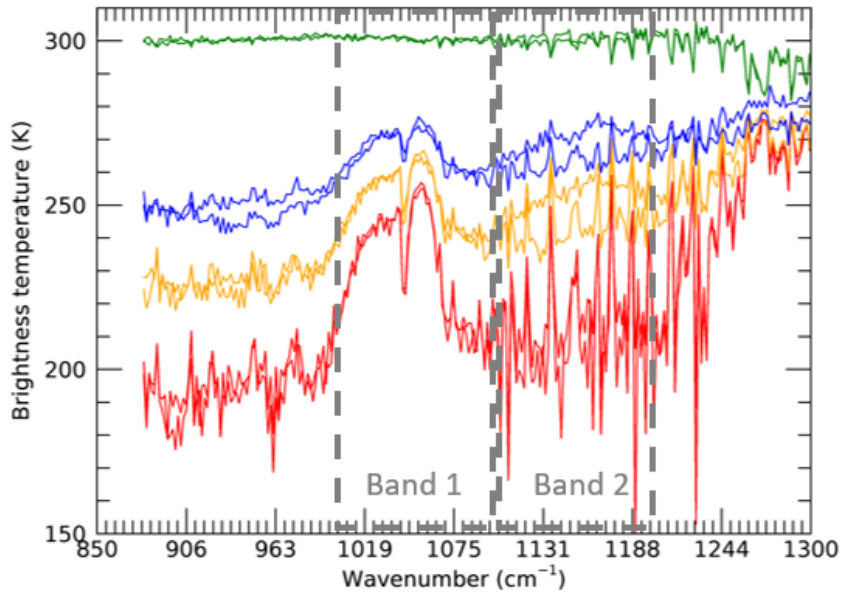
Library
SO_2 = f (I_{O3}, I_{SO2})





Band 1: 1000-1100 cm^{-1} — I_{O3} integral BT

Band 2: 1100-1200 cm^{-1} — I_{SO2} 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 SO_2 SCD retrieved using the library.
- ~ 15% of missing classes in the library (pixels in blue) mostly in dense plume part.



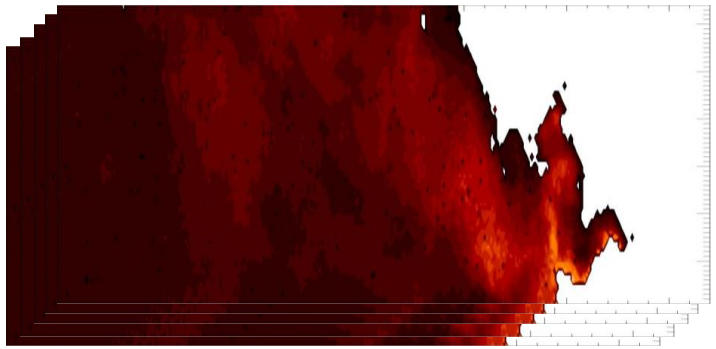


Dataset to analyze

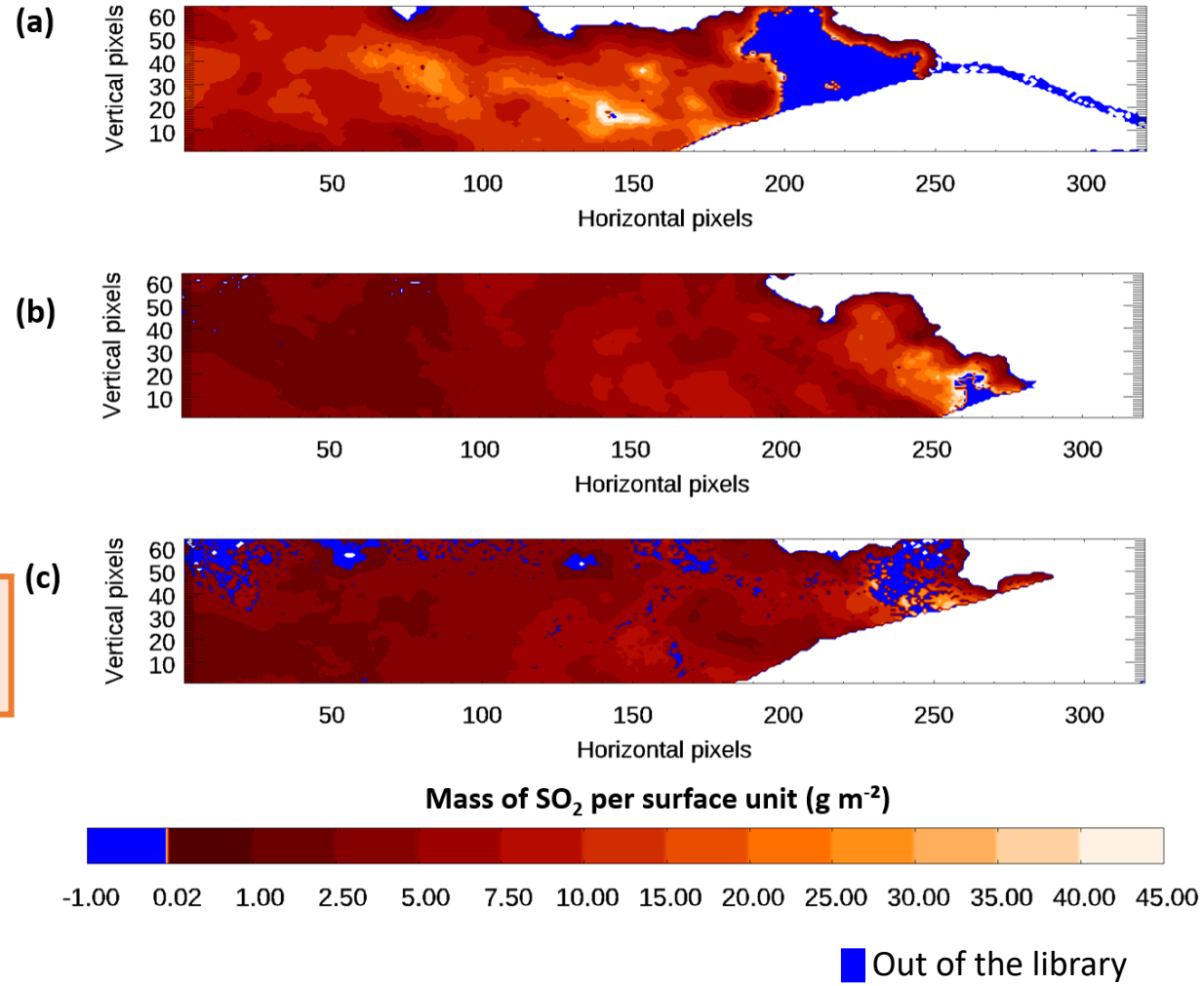
Spectral bands info extraction (for each pixel of each image)

I_{O_3} + I_{SO_2}

Library
SO_2 SCD = f (I_{O3}, I_{SO2})



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)





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