

Vulcamera: a program for measuring volcanic SO₂ using UV cameras

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ABSTRACT

We report here on Vulcamera, a stand-alone program for the determination of volcanic SO₂ fluxes using ultraviolet cameras. The code enables field image acquisition and all the required post-processing operations.

Remote spectroscopic observations of volcanic SO₂ fluxes are a mainstay of observational volcanology. Such data have greatly strengthened our understanding of volcanic dynamics and the impacts of volcanic degassing to the atmosphere [Tamburello et al. 2011a]. A recent development of note has been the imaging of volcanic plumes using ultraviolet (UV) cameras [Mori and Burton 2006, Bluth et al. 2007].

UV cameras can provide numerous benefits, such as: high time resolution, which enables the capture of transient explosive events [Yamamoto et al. 2008, Mori and Burton 2009]; the possibility to spatially resolve heterogeneous operations, e.g., fumarole field sources [Tamburello et al. 2011b], and single-point operations. Furthermore, the camera images can be used to directly measure the plume transport velocity, potentially a major source of uncertainty in these measurements [e.g., McGonigle et al. 2005, Williams-Jones et al. 2006].

Here we present Vulcamera, a stand-alone, user-friendly code for measuring volcanic SO₂ fluxes using UV cameras. The code consists of two elements: Vulcamera_aq and

Vulcamera_post, which manage the image acquisition and all of the elements of post-processing, respectively. Vulcamera is downloadable from <https://sites.google.com/site/giancarlotamburello/>, and it includes detailed instructions. Vulcamera will work with the Apogee Instruments U260 and E6 units; however, we recommend the U260, given its higher signal-to-noise ratio and faster data transfer. Vulcamera is designed to operate with two cameras, simultaneously, with bandpass filters centered on 310 nm and 330 nm. It is imperative to use two filters in these observations, to compensate for aerosol attenuation/backscattering, and this approach minimizes temporal mismatches associated with filter changes on a single camera [Kantzas et al. 2010].

In particular, the functions of the code include: characterization of vignetting via the collection of clear sky images to compensate for this angular dependency on pixel illumination; determination of the calibration relationships between absorbance and SO₂ cell concentrations, to enable conversion of the measured field images into ppm m concentration maps; use of simultaneously acquired spectroscopic SO₂ flux data to calibrate the images; and, finally, feeding back of all of these operations to the main page of Vulcamera_post, which leads to the computations of the SO₂ flux time series and gas masses associated with explosions.

Vulcamera has been extensively field tested with southern Italian volcanoes, and it is hoped that others will find this useful to realize the significant volcanological potential of UV camera technology.

VulCamera v 1.0

QUIT

Main (F3) Vignetting (F4) Calibration (F5) Plume speed (F6)

Graph A

Min Max

30000 25000 20000 15000 10000 5000 0

80000 60000 40000 20000 0

CHANGE SECTION

Cursors:	X	Y	Z
L	35	303	12956
R	454	185	13395

Graph B

Cursors:	X	Y	Z
Cursor	398	211	55690

Graph C

Ppm m

-2000 -1775 -1486 -1085 -844 -474 -200

Cursors:	X	Y	Z
Start	45	28	-1889
End	370	457	645
Cursor	856	739	-427

LOAD DOAS DOAS ppm m 85

Path: G:\Users\... File name: str5

image: 189 Shift X: -5 Shift Y: 10

pixels: 512 Rotate: 270 Flip: Horizontal

kg SO2: NaN Filter: 0 Ppm m

Sections graph

Amplitude A Amplitude B

60000 59000 58000 57000 56000 55000 54000 53000

0 50 100 150 200 250 300 350 400 450

A 310 nm B 330 nm

Section Ppm m/Absorbance

Amplitude

1000 800 600 400 200 0 -200

0 50 100 150 200 250 300 350 400 450

Cursors:	X	Y
Start	4	0
End	343	0
Base line	0	0

ICA [kg/m]

0.1 0.0 -0.1

11.8 11.9

Time

Ins intercept: 3750 Ins slope: 5830 ICA: 0.1520 Flux: 18.878

Ins pixel dim: 1.15 Plume speed: 1.4

Distance: 400 Height: 20 Lens FOV: 24

Pixel dim: 0.33253

Time: 13.6179 Time diff: 1.8036

Delay: 0 Limit: 50

SECTION HOLD ON SAVE MARK COERCE RESET

Figure 1 (previous page). Screen shot of the main screen of Vulcamera_post when in operation during the post-processing of volcanic degassing images from Stromboli volcano (Italy). Graph A and Graph B show the raw image files taken from the two cameras, with filters at 310 nm and 330 nm, respectively, showing the gas attenuation in Graph A. These images can be flipped as appropriate and are vignette corrected on the basis of operations that take place on the vignetting page. A profile across the rising gas plume is identified in Graph A using the L and R cursors, the intensities across which are presented in the profiles in the Section graph. The calibration data, as obtained from the calibration page, are entered into the appropriate fields to the centre-right of the screen, to generate both the pseudocolor graph of the concentrations across the images shown in the top right, and the concentrations across the L-R profiles in the Section ppm m/absorbance field. All of the above are then used to generate the integrated column amount time series of the explosive gas masses via the bottom-right window.

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