Vulcamera: a program for measuring volcanic SO_2 using UV cameras

Giancarlo Tamburello[1,*], Euripides P. Kantzas[2], Andrew J. S. McGonigle[2,3], Alessandro Aiuppa[1,3]

[1] *Università degli Studi di Palermo, Dipartimento DiSTeM, Palermo, Italy*

[2] *University of Sheffield, Department of Geography, Sheffield, UK*

[3] *Istituto Nazionale di Geofisica e Vulcanologia, sezione di Palermo, Palermo, Italy*

Article history
Received March 29, 2011; accepted May 16, 2011.
Subject classification:
Gases, Volcano monitoring, Instruments and techniques, General or miscellaneous.

ABSTRACT

We report here on Vulcamera, a stand-alone program for the determination of volcanic SO_2 fluxes using ultraviolet cameras. The code enables field image acquisition and all the required post-processing operations.

Remote spectroscopic observations of volcanic SO_2 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 SO_2 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 SO_2 cell concentrations, to enable conversion of the measured field images into ppm m concentration maps; use of simultaneously acquired spectroscopic SO_2 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 SO_2 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.

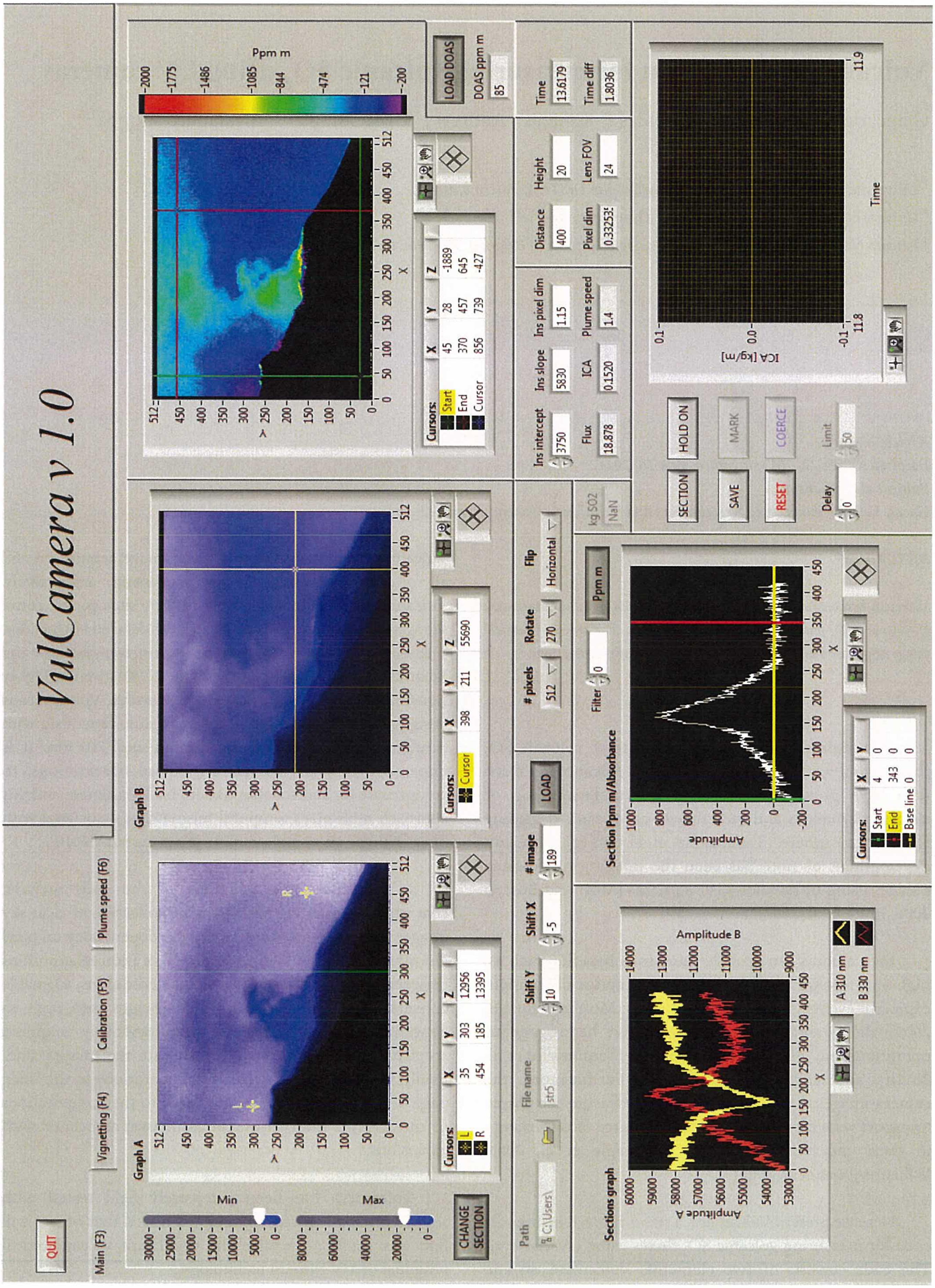
VulCamera v 1.0
QUIT
Main (F3)
Vignetting (F4)
Calibration (F5)
Plume speed (F6)
Graph A
Graph B
Min
Max
CHANGE SECTION
Path
File name
Shift Y
Shift X
image
LOAD
pixels
Rotate
Flip
Horizontal
Filter
Ppm m
Sections graph
Amplitude A
Amplitude B
A 310 nm
B 330 nm
Section Ppm m/Absorbance
Amplitude
Cursors:
Start
End
Base line
Cursor
Ppm m
LOAD DOAS
DOAS ppm m
Ins intercept
Ins slope
Ins pixel dim
Distance
Height
Time
Flux
ICA
Plume speed
Pixel dim
Lens FOV
Time diff
kg SO2
SECTION
HOLD ON
SAVE
MARK
RESET
COERCE
Delay
Limit
ICA [kg/m]
Time

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.

References

Bluth, G.J.S., J.M. Shannon, I.M. Watson, A.J. Prata and V.J. Realmuto (2007). Development of an ultra-violet digital camera for volcanic SO_2 imaging, J. Volcanol. Geotherm. Res., 161, 47-56; doi: 10.1016/j.jvolgeores.2006.11.004.

Kantzas, E.P., A.J.S. McGonigle, G. Tamburello, A. Aiuppa and R.G. Bryant (2010). Protocols for UV camera volcanic SO_2 measurements, J. Volcanol. Geotherm. Res., 94, 55-60; doi: 10.1016/j.jvolgeores.2010.05.003.

McGonigle, A.J.S., D.R. Hilton, T.P. Fischer and C. Oppenheimer (2005). Plume velocity determination for volcanic SO_2 flux measurements, Geophys. Res. Lett., 32, L11302; doi: 10.1029/2005GL022470.

Mori, T. and M. Burton (2006). The SO_2 camera: A simple, fast and cheap method for ground-based imaging of SO_2 in volcanic plumes, Geophys. Res. Lett., 33, L24804; doi: 10.1029/2006GL027916.

Mori, T. and M. Burton (2009). Quantification of the gas mass emitted during single explosions on Stromboli with the SO_2 imaging camera, J. Volcanol. Geotherm. Res., 188, 395-400; doi: 10.1016/j.jvolgeores.2009.10.005.

Tamburello, G., A.J.S. McGonigle, E.P. Kantzas and A. Aiuppa (2011a). Recent advances in ground-based ultraviolet remote sensing of volcanic SO_2 fluxes, Annals of Geophysics, this volume.

Tamburello, G., E.P. Kantzas, A.J.S. McGonigle, A. Aiuppa and G. Guidice (2011b). UV camera measurements of fumarole field degassing (La Fossa crater, Vulcano Island), J. Volcanol. Geotherm. Res., 199, 47-52; doi: 10.1016/j.jvolgeores.2010.10.004.

Williams-Jones, G., K. Horton, T. Elias, H. Garbeil, P.J. Mouginis-Mark, A.J. Sutton and A.J.L. Harris (2006). Accurately measuring volcanic plume velocity with multiple UV spectrometers, Bull. Volcanol., 68, 328-332; doi: 10.1007/s00445-005-0013-x.

Yamamoto, H., I.M. Watson, J.C. Phillips and G.J. Bluth (2008). Rise dynamics and relative ash distribution in vulcanian eruption plumes at Santiaguito Volcano, Guatemala, revealed using an ultraviolet imaging camera, Geophys. Res. Lett., 35, L08314; doi: 10.1029/2007GL032008.

*Corresponding author: Giancarlo Tamburello,
Università degli Studi di Palermo, Dipartimento DiSTeM, Palermo, Italy;
email: giancarlotamburello@gmail.com.