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Supplementary material to: Volcanic SO_2 and SiF_4 visualization using 2-D thermal emission spectroscopy. Part I: slant-columns and their ratios

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1 Video animations of the SO_2 plume in column densities

The film *SO2_volcanic_plume.mpg* shows 3 sequences of the SO_2 plumes emitted to the atmosphere. All measurements are taken from Altzomoni at 4000 m a.s.l. and 12 km North of the Popocatepetl volcano (5465 m a.s.l.). The false-color images are calculated automatically with the GeDetekt software and in all cases the (plume-sky) retrieval method used the column in the left border as sky spectrum for the evaluation of the pixels in the corresponding row.

1.1 Segment I (17 March 2006)

The first sequence of the video shows the volcano emitting SO_2 passively in rather windy conditions, when a wind speed of around 10 m/s at 500 hPa was recorded by a radiosonde launched at 12 LT (or 18 UT) from the airport 50 km NW of the volcano. It can be seen sometimes that the plume is separated downwind and that the wind direction depends on the altitude. Due to the rather fast propagation of the plume, the measured SO_2 columns remain moderate even though the volcano is quite active. The color-scale (black-blue-red-yellow-white) is not shown but covers the range 0 to 4E18 molec/cm^2).

1.2 Segment II (1-2 December 2007)

Night measurements of the volcanic SO_2 plume about half a day after a small eruption had taken place at 6:20 am LT (see Stremme et al. (2011)). This sequence shows more continuous and passive

degassing conditions at moderate and rather constant wind speeds. Only small variations occur in these sequence but providing the necessary information for wind-field retrievals and flux calculations (see Part II of the article).

1.3 Segment III (16-17 November 2008)

The last sequence shows measurements also during the night but on 16-17 November 2008. There are frequent interruptions for radiometric calibrations and the validation described in the article Sect. 4. As described in the text, a strong Vulcanian-type explosion occurred around 1:06 LT (7:06 UT), which happened during the shown sequence. The presence of ash, also shown as the white areas in Fig. 8, does not allow for the retrieval of the SO_2 columns and the plume is not seen in the animation because these pixels are colored in black by the software. At the edges of the measured window, however, large SO_2 column densities were evaluated. After the amount of ash had diminished (about 40 min. after the explosion), the strong light-colored SO_2 plume becomes evident. As the plume propagates towards the observation site, it presents a broad cone-like shape. The wind direction turned from SW at sun-set to the S two hours later or about midnight and again towards the SE at dawn, just before the animation stops. In this sequence , the color-scale covers the 0 to $6 \cdot 10^{18}$ molec./cm^2). A quantification from this sequence may have larger uncertainties since it is not well known with what temperature the SO_2 is emitted during the explosion and how fast the emitted SO_2 gas adopts the environmental temperature with respect to the passively emitted SO_2 in most of the other cases.

2 Video animation of simultaneous SO_2 and SiF_4 column densities

The simultaneous slant column distribution of the volcanic SO_2 and SiF_4 gases emitted by Popocatepetl is presented in the file *SO2_SiF4.mpg*. This animation is intended to demonstrate small differences in the temporal and spatial evolution of both volcanic gases, which as has been shown in the article, are emitted in different proportions depending on the activity of the volcano.

An enhanced SiF_4 emission is assumed to be related with Vulcanian-type explosions (text of article, Francis et al. (1996), Love et al. (2000) and Stremme et al. (2011)). The animation shows the false-color images of SiF_4 and SO_2 of the night 16-17 November 2008, as well as the brightness temperature reflecting the spacially-resolved amount of IR radiation received by the instrument. The eruption at 7:06 UT is also shown in the article (Fig.13) and in the previous video (S.1). It is evident that both gases have a different relative evolution throughout this event as can be confirmed by the temporal SiF_4/SO_2 plot in Fig.13. The eruption itself lasted for about 40 minutes and it took some more minutes until the ash separated from the gas plume. After the ash fell, the gas-plume appeared first at the top of the images. Later the SiF_4 plume slowly faded out while the SO_2 emission remained almost constant.

To suppress noise in the animation, the correlation coefficient between the SiF_4 reference spectrum to the measured spectra is used as threshold. All SiF_4 columns with values below 0.93 are set to 0. Since up to now no other eruptions have been recorded with an infrared gas imaging device, the experience in SiF_4-column measurements at 4 cm^{-1} is poor and a proper validation is missing. Therefore, the relatively change in the SiF_4 and not the absolute column values should be considered (see also text in the article).

References

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