A low-cost SO_2 imager with the use of digital cameras of consumer use

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Sulfur dioxide in volcanic plumes is generally hard to recognize with human eyes. In recent years, ground-based remote sensing of SO2 is mostly performed with DOAS instruments which measure the UV spectra along the line of sight (e.g. McGonigle et al., 2002). Besides, so-called SO2 cameras which composed of a CCD device and band-pass filters have been developed for imaging the SO2 concentration in a plume (e.g. Mori and Burton, 2006). The prime feature of the latter system is the visualization of SO2 gas as a snapshot, in which a plume shape is instantly recognized. Such an easy visualization of SO2 may contribute to the quick awareness of harmful gas from the vent as well as to the monitoring of volcanic activity. However, high-spec CCD devices are generally expensive and this is one of the reasons that prevent such SO2 cameras to be widely used by non-specialists. In this study, we produced an SO2 imager of a low-cost version by means of digital cameras of consumer use.

In our system, we introduced the model D70 (Nikon), as a light-receiving CCD device. The dimension, number of pixels, and brightness resolution of the CCD are 23.7 by 15.6 mm, 6.27 M pixels, and 12 bit, respectively. Some modifications are necessary in order to enable the camera to sense the UV lights. First of all, a built-in optical low-pass filter must be removed manually. Appropriate lens and filters which permit UV bands should be chosen. We used a compound lens (Nikon UV-105 mm, F4.5) and band-pass filters (FWHM: 9 nm, max transmission rate: 65%, blocking: 10^{-5}) to extract the 310 and 330 nm bands separately, with additional two band-pass filters for each to cut unwanted wavelengths. The former band has a higher absorbance by sulfur dioxide than the latter. We adopted simultaneous shooting system with the use of two cameras to overcome a somewhat long exposure time (5 to 10 sec) required. Additional ND filters were added to adjust the exposure times of the two bands to be approximately the same. Since images can be taken in the same way as ordinary photographing and stored in the build-in memory card, this device can operate without external power or control PCs, and thus, is suitable for mobile use.

Calibration of our device with SO2 cells of known column concentration confirmed a comparable absorption coefficient to the device which was previously invented by Mori and Burton (2006). We also performed a field test of the system in Sakurajima volcano, southwestern Japan and confirmed its validity as an SO2 imager. However, a special care with the UV scattering in front of a plume (e.g. Mori et al., 2006) is necessary for fully quantitative applications in a field operation. A simultaneous operation with DOAS system might be another option to ensure the quantitative capability. Meanwhile, further cost-down is also possible by replacing an optical system into a single silica lens by compromising on the optical distortion and aberration.