Measurement of volcanic gas using differential optical absorption spectroscopy (DOAS) with a Xenon light source

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On July 14, 2000, Mt. Oyama in Miyakejima island began a series of eruptions, leading to complete evacuation of the residents by September. After a four-year period of continuing volcanic emissions, residents were allowed to return permanently on February 1, 2005, and about 2, 845 people live in Miyakejima as of January 2009. After the eruption, there has been a constant flow of sulfuric gas from the crater of Mt. Oyama. As of today, a large amount of SO2 emission from 1,000 to 3,000 tons/a day continues. At the foot of Mt. Oyama, there still exist regions where the volcanic gas frequently reaches depending on the wind conditions. Such regions are called high density districts, and entry therein is strictly regulated. It takes six and a half hours by ship to transport from a port along the Tokyo Bay to Miyakejima. The aircraft service was restarted in May 2008, resulting in a much shorter time of 45 minutes. Due to the influence of the volcanic gas, however, only about 42 % of the flights were actually implemented in December 2008 (Miyake official report, Vol.467).

The drawback of the use of aviation obstruction light as a DOAS source, however, is that in accordance with the regulation, the light intensity is diminished at dusk and dawn, and during the nighttime, blinking red lights replace the flashlights. Moreover, the measurement cannot be carried out where no obstruction flashlight is situated. Alternatively, here we propose the use of a commercially available Xenon flashlamp as a white-light source. This is relatively inexpensive, yet the possibility of unattended, continuous operation is quite suitable for the DOAS measurement. This light source is portable, and it can be used during both day and nighttime. For the measurement of SO2 concentration, a telescope having enhanced reflectance in the UV spectral region (around 300 nm) is employed instead of the conventional, astronomical telescope used for the visible measurement.

In order to understand the influences of the volcanic eruption on surface areas both temporally and spatially, here we investigate the vegetation properties by using ASTER data after 2000 when Miyakejima erupted, in relation to the in-situ observation on regional concentrations of air pollutants.

We report the result of a recent campaign in Miyakejima conducted in December 2008. Concentrations of volcanic gases were measured with a UV telescope and the capability of the Xenon flashlamp as a DOAS light source was tested. The DOAS result is compared with the ground sampling measurement. At the same time, ASTER visible and near-infrared (VNIR) data are used to calculate the normalized difference vegetation index (NDVI) for areas around the ground sampling points to study the vegetation conditions in relation to the concentration records of the volcanic gas (SO2). A nearly horizontal optical paths in a height range of 10-50 m from the ground level was employed to measure the optical thickness due to SO2 and NO2 absorptions and aerosol extinction in the atmospheric boundary layer. When there was no volcanic eruption, the background levels of both SO2 and NO2 were below the environmental standard. During 2-7 a.m. on December 11, however, we observed high concentration of SO2. The DOAS optical path length was 460 m inside the high density district Tsubota, and the observed value was in a range of 40 - 1600 ppb. In contrast, the concentration of NO2 was rather limited (10 - 30 ppb). For SO2, a reasonable temporal correlation was found between the DOAS result and the data from a ground station near the optical path. Comparison with the NDVI distribution using the ASTER data has revealed that low NDVI values are seen in the high density districts (Tsubota and Ako), while in other areas where influence of the volcanic gas is limited, higher values of NDVI are observed.