Numerical Simulation of Volcanic SO2 Dispersion over the Miyake Island

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After severe eruptions of the volcano at the Miyake Island in August 2000, a large amount of volcanic gas has been released into the atmosphere. The estimated emission rate of volcanic sulphur dioxide (SO2) reached several tens of thousand ton/day in the autumn of 2000. More than a ten thousand ton/day of SO2 gas kept emitting still in 2002. High concentration of SO2 gas over the island prevents the residents from returning to the island. For the safety on the Miyake Island, knowledge of the distribution and concentration of SO2 gas was required.

To simulate flow and dispersion of SO2 gas over the Miyake Island, a set of numerical models was developed. The multi-nesting method was adopted to reflect realistic meteorological field and to resolve sufficiently the flow over the island with a diameter of 8km. The outermost model was the Regional Spectral Model (RSM) of the Japan Meteorological Agency (JMA) with a horizontal grid size of 10km. Finer atmospheric structure was simulated with the nonhydrostatic model jointly developed by the Meteorological Research Institute and the Numerical Prediction Division of JMA (MRI/NPD-NHM) with grid intervals of 2km, 400m and 100m. Lagrangian particle model was applied to the dispersion model, which was driven by the meteorological field of the 100m-grid MRI/NPD-NHM. The random walk procedure was used to represent the turbulent diffusion. The dry deposition process was implemented. The wet deposition was, however, excluded in the present simulation, because little condensation and precipitation were expected in the selected cases. Steady emission of SO2 gas from the crater in the center of the island was assumed. Taking into account thermal deviation of the volcanic plume, rising velocity of the tracer particle was parameterized. Effective radius of the emission was dependent on the diffusivity at the source area in the present model, because the volcanic gas was considered to be suffered mixing with ambient air due to the turbulent motion just after the release from the crater.

The model was validated in four cases. Simulated SO2 concentrations agreed well with observed concentrations at a monitoring station including temporal variation. Under a large synoptic change, however, accurate prediction became difficult. To investigate the characteristics of the flow and the distribution of SO2, further numerical experiments have been done. Steady inflows, classified according to surface wind speed and direction, were assumed. Mean wind and temperature fields over the Miyake Island were evaluated from the Global objective analysis data for each surface wind category. Simulated SO2 distribution on the ground apparently depends on the surface wind over the island. Under relatively weak inflow, there is a large diurnal change in the SO2 distribution, affected by the thermally induced flow. The SO2 gas is widely spread downstream in the nighttime but hardly reaches the coastal area in the daytime. On the other hand, little diurnal variation could be seen under the stronger inflow. Ground temperature, as well as the static stability of the inflow, also influences downstream wind, turbulent diffusivity and consequently, the SO2 distribution.