Sensitivity study of eruption source parameters in numerical models for volcanic ash transport and deposition

K. B. Moiseenko [(1)], N. A. Malik [(2)]

[(1)] Obukhov Institute of Atmospheric Physics RAS, Moscow, konst.dvina@mail.ru
[(2)] Institute of Volcanology and Seismology FEB RAS,
Petropavlovsk-Kamchatsky, malik@kscnet.ru

Ash clouds due to volcanic eruptions are one of the major natural hazards affecting human activity. During volcanic eruptions, volcanic ash transport and dispersion models are commonly used in order to forecast ash propagation through the atmosphere downwind over hours to days to assess potential hazards to aircraft and human health. To predict correctly the ash cloud's propagation, these models require various source parameters to describe initial distribution of gaseous and aerosol compounds in the atmosphere in the vicinity of eruption. Unfortunately, the definition of key source parameters in particular events is not a trivial task due to lack of information on eruption cloud height, particle size distribution, start and end time of the eruption as well as its intensity. In this study, we use Hybrid Particle and Concentration Trasport (HYPACT) model which is a part of Regional Atmospheric Modeling System (RAMS6.0) to study sensitivity of eruption source parameters for volcanic ash transport prediction.

The results of numerical calculations for ash propagation are compared against the sample measurements conducted immediately after explosive eruption events on Bezymianny Volcano (Kamchatka) on 24 December 2006 and 17 December 2009, Karymsky on 21 April 2007, and Kizimen on 13 January 2011. It follows from the both model simulations and measurement data that the different assumptions on vertical mass distribution in the eruptive column can result in dramatically different ashfall patterns for the particles whose size ranges from 5 – 250 μm. The general notion is that the light particles (up to 50 – 70 μm) are distributed rather uniformly in the eruptive column, whereas for the larger particles there is a tendency for the eruptions of moderate intensity to accumulate in the first 3 – 4 km above the vent. Such non-uniformity is a result of complex interplay between two opposite factors: upwind convective transport and downward sedimentation due to gravity force. Volcanic particles aggregation in the event on Bezymianny 2006 seems to have dramatic effect on ash deposition resulting in enhanced deposited density values in the vicinity of the volcano. We use the inverse procedure based on least squares approach to restore total volume of erupted ash from computed and observed loadings. The obtained values for the eruption rates are in a good agreement with those obtained independently basing on observed terminal heights of eruption columns. This may serve as indication of good model performance in its ability to predict ash cloud transport and dispersion, as well as to restore total amounts of erupted tephra with use of the inverse modeling approach.

As example, estimations for source mass discharge rate based on plume height have been conducted for eruption event on Bezymianny Volcano (Kamchatka) on 24 December 2006 are considered briefly. The maximum height H of volcanic column was about 10 – 13 km based on visual inspection and satellite images of the volcanic plume. The atmospheric sounding at Kljuchi shows a tropopause at 8.8 km (280 mbar), so the terminal height of the volcanic column was well above the tropopause level. Invoking the relation between the

source mass discharge rate Q [kg/s] feeding volcanic column and maximum height (Carazzo et al., 2008, J. Geophys. Res. 113, B9) for the mid-latitude lapse rates,

$$Q = a H^4, \qquad (1)$$

where a=74 kg/s/km^4 (H<12 km), and time duration of the event 50 min, we obtained the value of 2.12 Mt as a rough estimate for the upper limit of total amount of ash particles emitted. Basing on best-fit arguments (see Figure 1), the total amount of ash particles (with the diameter less then 1 mm) emitted was about 1.75 Mt which is consistent with the above estimate (2.1 Mt) with use of Eq.(1).

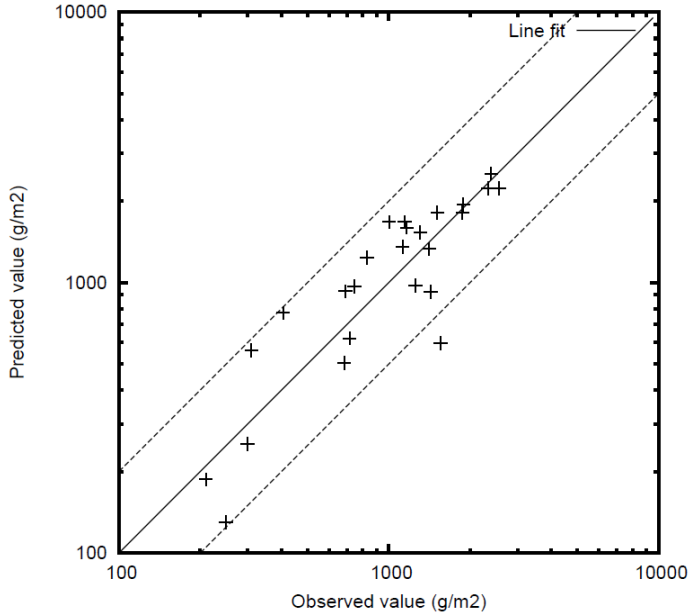

Figure 1. Comparison between computed and observed ground ash loadings based on the ash samplings around Volcano Bezymiannii after the explosive eruption event on 24 Dec 2006. Dashed lines indicate over- and under-estimations of ½ and 2 times the observed values.