Features of Numerical Model “Ballista”; the Ballistic Simulator of Explosive Volcanic Eruption

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Ballistic projectiles are emitted from the vent of the volcano when an explosive eruption occurs. Their sizes range from a few centimeters to several meters, and the landing velocity of these pyroclasts can exceed 100 km/h. Therefore, for hazards and disaster risk management it is essential to estimate the affected area of ballistic projectiles. To reach this goal the ballistic trajectory simulator “Ballista” was developed. This model can calculate the trajectory and deposition condition of multiple ballistic particles in three dimensions using a momentum equation including air friction solved by the Runge-Kutta method, and particles are transported by the Lagrangian method. Ballista was programmed using Java to increase portability and includes complementary modules, such as a topographic effect, which is also taken into account by the simulation. As a result, the model can constrain the ejection angle and direction bearing of ballistic projectiles released during the Ontake 2014 eruption (Tsunematsu et al., 2014), not only using ballistic physics but also realistic terrain data.
In the presentation, we show how local conditions and terrain can affect the model by running the same simulations with and without topography, but also by modifying the resolution of the topography to study these effects. The resolution of the digital elevation model (DEM) only changes the large scale distribution of ballistics on the ground when the grid size is fairly large (> 100 m). Results also show that including topography in the calculation changes the travel distance and the spatial distribution of particles significantly. When examined in detail, in particular locations the high resolution DEM can be used to identify shelter areas where ballistic hazard is reduced, for example, behind large boulders or buildings - risk reduction strategy that proved successful for hikers caught in the 2014 eruption. In our presentation, we discuss such topographic dependency of the Ballista quantitatively.
Finally, we have made the model public by a creating graphical user interface and a user guide in order to contribute to the disaster risk management.

Keywords: Ballistc projectiles, Explosive eruption, Topography, Resolution, Numerical Model, Graphical User Interface

