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Multiphase flow dynamics and damage zonation of the May 18, 1980 lateral blast of Mount St. Helens: comparison between 3D numerical simulations and field observations

Tomaso Esposti Ongaro[1], Augusto Neri[1], Amanda B. Clarke[2], Jean-Francois Smekens[2], Barry Voight[3], Christina Widiwijayanti[4]

[1] *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy*
[2] *Arizona State University, Tempe, USA*
[3] *Penn State University, University Park, USA*
[4] *Earth Observatory of Singapore, Nanyang Technological University, Singapore*

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Volcanic directed blasts are among the most hazardous and fascinating of volcanic phenomena. They are characterized by an extraordinarily large rate of mass and energy discharge, extremely fast dynamics and a remarkably broad area of severe damage, despite the relatively low amount of magma involved. The rapid decompression and expansion of the eruptive mixture and the subsequent propagation of the pyroclastic density current are characterized by complex thermo-fluid dynamics, involving the propagation of a multidispersed mixture of gas and particles and interaction with the rugged, 3D topography. In this study, we adopt a 3D, transient model (Neri et al., J. Geophys. Res., 2003; Esposti Ongaro et al., Parallel Computing, 2007) based on the Eulerian multiphase transport equations to reconstruct "a posteriori" the dynamics of the well-documented May 18, 1980 blast at Mount St. Helens (USA). The detailed comparison of 3D model results with digitized, geo-referenced observational data demonstrates the ability of the model to reproduce the MSH blast front advancement and basic deposit characteristics and distribution, with initial conditions well constrained by available geologic data (including gas content, mass of juvenile and entrained rocks, temperature, grain size distribution, and pre-eruption pressure distribution in the cryptodome). The simulations suggest that much of the severe damage observed at MSH can be explained by high dynamic pressures in stratified gravity currents, and that the rapid decrease in damage and dynamic pressure from proximal to distal areas may be related to rugged topography beyond the North Fork Toutle River valley. Despite the considerable number of uncertain parameters in the model and in the observations, our present results demonstrate that 3D transient and multiphase flow models can accurately reproduce the main large-scale features of blast scenarios and can help in the definition and assessment of flow hazards at blast-dangerous volcanoes worldwide.