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From field data to numerical models: application of the Box-Model to infer the dynamics of PDC generated during the AD 79 eruption of Somma-Vesuvio

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The purpose of this work is to present a validation procedure for a physical and numerical model of Pyroclastic Density Currents (PDC) using feedbacks from well-known deposits emplaced by specific single eruptive units. The study is specifically focused on the PDCs generated during the overall famous AD 79 eruption of the Somma-Vesuvio volcano. To this purpose, values of the maximum runout, volumes and Total Grain Size Distributions have been estimated for two eruptive units (i.e. EU3pf and EU4; Cioni et al. 2000) of the AD 79 eruption. These units have been used to define the input volcanological parameters for testing the Box-Model of Dade and Huppert (1995), when reproducing one specific end-member of the complex spectrum of PDCs, that is the more dilute, turbulent part of the PDCs reconstructed in the Somma-Vesuvio record (stratified flows with concentration of solid particles in volume up to about 5%). The Box-Model is a kinematic approach, which calculates the flow density and velocity along time and the kinetic energy of the flow front. This can be compared with the potential energy needed to overcome topographic obstacles to estimate flow invasion across complex topographies. Validation of the model has been performed with respect to: i) the degree of overlapping between inundation areas given by the model and by field data; ii) the thickness of the deposit versus the thickness of the model output with distance; iii) the mass fractions of the different grain size classes with distance in the real deposit versus the model output. Several simulations have been performed considering i) polydisperse (with 10 grain size classes) and monodisperse (with the Mdφ values) systems; ii) a direct version (where the initial volume is released and the invasion area is computed) and an inverse version (where the initial collapsing volume is a function of an inundation area defined by the user); iii) axisymmetrical and asymmetrical collapses. Results allow to obtain first order estimates of the main variables characterizing the flow source and emplacement; among the two eruptive units chosen for model validation, the EU4 provided better results with only a minor empirical calibration of few parameters (i.e. settling velocity and initial volume fraction of solid particles), indicating that the Box Model can be suited to represent the kinematics of large (volume > $\sim 10^8$ m^3, runout > $\sim$15 km) PDC at Somma-Vesuvio.

Dade W. B., Huppert H. E. (1995) A box model for non-entraining, suspension-driven gravity surges on horizontal surfaces. Sedimentology 42 (3):453-470

Cioni R., Marianelli P., Santacroce R., Sbrana A. (2000). Plinian and subplinian eruptions. Encyclopedia of volcanoes. Academic, San Diego, 2000, 477-494.