# Inversion of field data for reconstructing plume dynamics of past eruptions: state of the art and perspectives

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Eruptive columns commonly comprise three distinct regions characterised by different flow regimes: a lower basal gas-thrust or jet region, an intermediate convective region, and an upper umbrella region. Typically, the gas-thrust region extends only up to a small fraction of the total column height and it is characterised by a steep decrease of the gas particle mixture velocity due to loss of momentum. In contrast, the convective region is dominated by buoyancy forces acting on the hot erupted gases and heated entrained air. Finally, above the neutral buoyancy level, the erupted material spreads under the effect of winds and atmospheric turbulence to form the umbrella region. Sizes of erupted particles may vary by several orders of magnitude, ranging from very fine sub-micron ash to clasts larger than one meter in diameter. The largest and heaviest particles leave the column at lower levels and follow complicated ballistic and non-ballistic trajectories, whereas the finest particles may remain entrapped by geostrophic winds for several years affecting the global climate. Particles within the intermediate to fine size range are advected by wind, diffused by turbulence, settled by gravity and deposited finally on the ground at medium to distal distances. Therefore, the physics of volcanic plumes depends by different several factors, which can be summarised as total mass and its distribution (total grain size), initial momentum, available heat, efficiency of air entrainment and interaction with the atmospheric wind field. The definition of these parameters is essential for having models able to predict ground ash loading and atmospheric ash concentrations, which are of fundamental importance for public safety in volcanic areas. However, The characterisation of these parameters is hard to obtain from direct observation of eruption plumes, and are even more challenging to gain from inversion of data from pyroclastic deposits.

Here, a critical overview about models (field, experimental and numerical) for inversion of field data to gain insights on the physics of volcanic plumes is proposed. A special focus is devoted to some physical parameters that are far from a satisfactory inversion (e.g. reconstruction of total grain size distribution), and clues for future research are suggested.