



The integral suspension pressure method (ISP) for precise particle-size analysis by gravitational sedimentation

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The particle-size distribution (PSD) of a soil expresses the mass fractions of various sizes of mineral particles which constitute the soil material. It is a fundamental soil property, closely related to most physical and chemical soil properties and it affects almost any soil function. The experimental determination of soil texture, i.e. the relative amounts of sand, silt, and clay-sized particles, is done in the laboratory by a combination of sieving (sand) and gravitational sedimentation (silt and clay). In the latter, Stokes' law is applied to derive the particle size from the settling velocity in an aqueous suspension. Traditionally, there are two methodologies for particle-size analysis from sedimentation experiments: the pipette method and the hydrometer method. Both techniques rely on measuring the temporal change of the particle concentration or density of the suspension at a certain depth within the suspension. In this paper, we propose a new method which is based on the pressure in the suspension at a selected depth, which is an integral measure of all particles in suspension above the measuring depth. We derive a mathematical model which predicts the pressure decrease due to settling of particles as function of the PSD. The PSD of the analyzed sample is identified by fitting the simulated time series of pressure to the observed one by inverse modeling using global optimization. The new method yields the PSD in very high resolution and its experimental realization completely avoids any disturbance by the measuring process. A sensitivity analysis of different soil textures demonstrates that the method yields unbiased estimates of the PSD with very small estimation variance and an absolute error in the clay and silt fraction of less than 0.5%