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3D visualization of air injection in a deformable refractive-index-matched porous media via laser scanning

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The present work implements and validates a visualization method to obtain the dynamic three-dimensional (3D) structure of the injected air plume with a given temporal/spatial resolution. The air plume develops via continuous air injection through an orifice at the bottom of a loose packing of crushed silica grains. This grain packing is then saturated by a glycerine-water solution having the same refractive index, and placed in a 200 mm (width) $\times$ 200 mm (depth) $\times$ 300 mm (height) glass container. By using high-speed image acquisition combined with laser scanning, the dynamic air plume is recorded by sequential topographic imaging. Three image processing methods are presented for the removal of redundant pixels, and the results are discussed by comparing them both with respect to the obtained morphology and the measured air volume. After processing, a 3D dynamic air flow pattern can be obtained, allowing a quantitative analysis of the air flow dynamics on pore-scale. In the present experimental configuration the temporal resolution is 0.1 s, and the spatial resolution is about 0.1 mm in plane and about 1 mm out of plane of the laser sheet. It is worth to mention that the migration phenomenon of air channel [Kong et al., Chem. Eng. Sci., 64, 1528-1535 (2009)] is confirmed in our 3D experiments.