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Topological metrics for the characterization of three-dimensional flow fields in porous media

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In this work we present and apply three metrics for the characterization of topological features of three-dimensional flow fields in porous media. In particular, we consider the helicity density, which is defined as the scalar product between the specific discharge vector and its curl, stretching, which quantifies the increase of the length of an interface, and folding, which describes how this interface is bent in order to fill a finite volume of space. These three metrics provide complementary information: Helicity density provides local information about the torsion of streamlines, while stretching and folding describe the global deformations of stream tubes. Flow in three-dimensional porous media shows a complex topology and its characterization is useful to describe deformation of solute plumes and, consequently, mixing and mixing enhancement processes.