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Parametric study of barometric pumping of a fractured porous medium

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Fluctuations in the ambient atmospheric pressure result in motion of air in porous fractured media. This mechanism, known as barometric pumping, efficiently transports gaseous species through the vadose zone to the atmosphere. This is of interest in fields, such as transport of trace gases from soil to atmosphere, remediation of contaminated sites, radon in buildings, leakage from carbon sequestration sites and detection of nuclear explosions.

The fractures are modeled as polygonal plane surfaces with a given transmissivity embedded in a permeable matrix. The slightly compressible fluid obeys Darcy's law in these two media with exchanges between them. The solute obeys convection-diffusion equations in both media again with exchanges.

The numerical methodology is briefly described. The fractures and the porous medium are meshed by triangles and tetrahedra, respectively. The equations are discretized by the finite volume method and a Flux Limiting Scheme diminishes numerical dispersion.

This model is applied to the Roselend Natural Laboratory. At a 55 m depth, a sealed cavity allows for gas release experiments across fractured porous rocks in the unsaturated zone. The standard case consist of hexagonal fractures with a radius of 5m, of aperture 0.5 mm and of density larger than 2.4 10-3 m-3; the pressure fluctuations are sinusoidal, of amplitude 0.01 bar and period 1 week; the solute concentration is equal to 1 at the bottom.

Systematic results will be presented. First, the precision of the calculations is assessed. Second, the pressure and solute concentration fields are displayed and discussed.

Within the time limit, the influence of the major parameters (fracture density, aperture, porosity, diffusion coefficient, pressure fluctuations including real recordings, ...) is illustrated and discussed relatively to the standard case. Emphasis is put on some paradoxical results which are obtained.

These results are discussed in terms of the amplification of solute transfer to the ground surface by the pressure fluctuations.