# Numerical modeling of air flows in an underground cavity connected to the surface by a shaft

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The Normandie region contains a lot of chalk cavities that were dug by farmers to fertilize Fields. However those cavities have a low dimension (2-3 meters height)/depth (20-40 meters depth) ratio witch make their detection very challenging with the classical geophysical methods.

Due to the global warming there will be more precipitations leading to the collapse of the cavities causing the death of humains, thus their detection is a priority.

The Cerema center in France is testing an alternative method based on thermal infrared observations by drone[1]. So the aim of our model is to derive naturally thermal convection models in an underground cavity starting from available models at LMRS[†] in order to quantify the hydrothermal process at play in those cavities to compare it with the results of the drone. These numerical codes using finite elements make it possible to solve the Navier-Stokes equations and the heat equation in a fluid medium and a porous medium in 2D and 3D with a condition of solar radiation at the surface. Numerical simulations were carried out with the free software FreeFem++[2].

The Figure 1 below shows the result of the simulation where we can see the triggering of natural air convection within and underground cavity opened to the atmosphere with an intensification of the airflow velocity with time and decreases with the downstream distance, respectively and a number of cells of convection that change with time and the Rayleigh number. And so by comparing our result of the temperature to the one obtained with the drone we can test if our model can be used to see the drone capability of detecting these underground cavities.

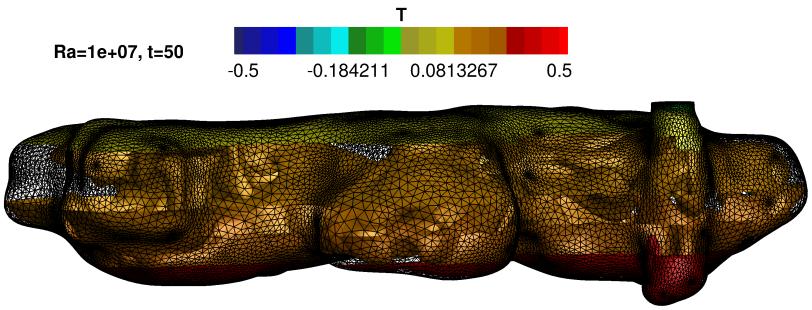


Figure 1: Air circulation at t = 50s for natural convection simulated in the Barcq cavity (27170 - Eure - France) 3D with Rayleigh = 1.e7.

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[1]C. Fauchard et al., *Guide technique- Laboratoire central des ponts et chaussées.*, (2004).
[2]F. Hecht *et al.*, *FreeFem++*, *Journal of Numerical Mathematics* 20:251–266 (2012).