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Mixed-dimensional modeling of the brain's waterscape

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The clearance of the metabolic waste in the body is handled by the lymphatic system. Except in the brain, which appears to be the only organ devoid of lymphatic channels. Indeed, the mechanisms underlying the clearance processes of the brain are still unknown, and the topic sparks debate and controversy. What is clear however, is that dysfunction of cerebral metabolic waste clearance is associated with neurodegenerative disorders such as Alzheimer's disease.

The term the brain's waterscape refers to the circulation, flow and exchange of tissue fluid and transport of solutes through the brain. While these processes are not fully understood yet, most hypotheses point out the major role of the cerebral blood vessels and possibly paravascular spaces. We propose to investigate these processes using a mathematical approach based on coupled mixed-dimensional models mimicking the vasculature and paravasculature as topologically one-dimensional structures embedded in a three-dimensional porous medium.

This poster presents a mixed-dimensional model dedicated to the mesoscale-macroscale interaction between the brain tissue, the vasculature and the paravasculature, aiming at gaining new insight into the waste clearance process of the brain. The formulation and well-posedness of this model will rely on non-standard techniques such as weighted Sobolev spaces and non-local averaging operators used in [1].

References

[1] D'Angelo, C. and Quarteroni, A. (2008). On the coupling of 1D and 3D diffusion-reaction equations: application to tissue perfusion problems. Mathematical Models and Methods in Applied Sciences, 18(08), 1481-1504.

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