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Entropy production and the analysis of convection in hydrothermal systems

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Convection in hydrothermal systems can have a significant influence on subsurface temperature distribution. Furthermore, convection patterns tend to exhibit complex nonlinear behaviour in space and time. However, the determination of a meaningful measure to characterize convection patterns in complex subsurface structural settings is not straightforward. It is therefore difficult to determine (a) how sensitive a system is with respect to uncertainties, and (b) connected to this question: how well we would be able to estimate subsurface temperatures in these systems – an essential problem in the context of geothermal exploration.

We evaluate here how thermal entropy production, as a measure of dissipative processes in a hydrothermal system, can be applied to characterise overall flow field stability in hydrothermal systems. The idea is based on the realisation that entropy production is minimal in a conduction-dominated system. As soon as convection is present, a hydrothermal field will reach an average value for specific entropy production, depending on convection strength and the patterns of convection cells.

An application to simulations of convection in confined porous media systems indicates that entropy production provides a suitable way to characterise convection in hydrothermal systems. Future work will address a formal analysis of convection patterns in geothermal systems, specifically addressing the question: how sensitive are convective patterns with respect to uncertain structural and petro-physical parameters?