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Large-scale use of heat as a natural tracer of groundwater flow: Application to a Variscan terrane in Belgium

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Heat flow shifts between 20 and 60 mW/m^2 in the upper ~2 km of the crust and 60 to 150 mW/m^2 at greater depth have been observed in the Soumagne, Havelange and Grand-Halleux deep wells, all located close to the Variscan thrust front in Belgium. A potential explanation for these anomalies might be provided by the existence of pervasive flow in the upper part of the crust, based on the concept of concave tectonics, and the flow through karstic pathways or major thrust faults. On the other hand, the paleoclimate is also known to disturb temperatures in the subsurface. To test the hypothesis that these processes are the cause of the observed anomalies, and to quantify the contributions of the different processes and flow paths, we performed large-scale 2-D coupled hydrothermal modelling of the current fluid and heat flow distribution. In order to account for the paleoclimate effect, we performed transient modelling, making use of paleotemperature data as boundary conditions. The results confirm that groundwater flow is the dominant cause of the observed heat flow shifts in the upper ~2 km of the Variscan terrane. The estimated groundwater flow, both pervasive and along major conduits, is rivalled by the paleoclimatic influence only in the Grand-Halleux well. The currently observed cooling of the upper ~2 km, requires less than 0.5 Myr and is controlled by the present geomorphology.