Dear Fabien Magri,

Thank you very much for your thorough review of the manuscript, your helpful comments and suggestions for further work, which have contributed to its improvement.

General Comment

The manuscript by Galsa et al. presents a detailed numerical investigation into the interaction of topography-driven groundwater flow and thermohaline convection. Usually this process is referred to as "mixed convection".

Yes, groundwater flow is considered a mixed convection system if it involves both forced convection (advection in physics) and free convection. However, we find it useful to distinguish between mixed convection regimes in which the flow is controlled by topography-driven forced convection and haline buoyancy (topohaline convection), or by topography and thermal buoyancy (topothermal convection), or even by all three components as topothermohaline convection. Thus, we can distinguish the driving forces in the umbrella term of 'mixed convection regime'.

Specific Comments

- **Temperature-dependent viscosity**

Yes, the assumption of a constant dynamic viscosity of water is indeed a simplification of reality, as it was stated in the original version of the manuscript. The reason for this was to be able to investigate the dynamics of topothermohaline convection over the widest possible parameter range (water table amplitude, heat flux and salt concentration) with the available computational resources (for some models where the computation converged slowly to the quasi-stationary solution, the CPU demand of the simulation was 2–3 weeks on an Intel Server with 2 Xeon Gold 6334 CPU @ 360 GHz using 32 threads).

On the other hand, due to the importance of the question raised, we decided to investigate the effect of the variable viscosity on the BTK model result. In the modified model, the viscosity of the water is now dependent on temperature, pressure and salt concentration (Likhachev, 2003; Adams and Bachu, 2002; Palliser and McKibbin, 1998). We found that the dynamic viscosity of the water in the parameter range under investigation is mainly influenced by temperature. Thus, in the regions of higher temperature, the viscosity of water decreased, which intensified the thermohaline convection within the confined geothermal reservoir, contributing to a decrease in the extent of the temperature anomaly and an increase in the salt flux entering through the lower boundary. The more intense flow reduced the water age in the reservoir. As the viscosity of the colder waters near the surface increased, the outflow salt flux was reduced, and the average salt concentration of the basin increased slightly. However, these changes have not altered the conceptual bigger picture established in BTK, which is that (1) topography-driven water flow is the dominant driving force in unconfined karst, while (2) thermohaline convection is the dominant flow regime in the confined reservoir, (3) the clayey Oligocene cover is saturated with saline and aged synsedimentary waters, and (4) young, cold and fresh waters from the western side are mixed with aged, hot and saline waters from the eastern side in the confined karst. (5) The water, mixed in temperature and chemical composition, continues to reach the surface in the main discharge zone along the Danube. The results of the simulation with $\mu(T,p,c)$ are presented and interpreted in the new Supplementary material attached to the manuscript, and the main conclusions are also presented in the Discussion part of the revised manuscript.

- **Boundary Conditions in Table 2**

In the synthetic simulation series, the bottom salt concentration was fixed and varied over a very wide range (c_b=2–200 g l^{-1}) in the parameter analysis to cover as many hydrogeological situations as possible, from quasi-freshwater saturated basement to evaporites (e.g. 280–345 g l^{-1} for Zechstein salt in Zech et al. (2016), Kaiser et al. (2013)). The c_b=70 g l^{-1} chosen for the base model is an 'average' value between the two extremes, which could dominate the groundwater flow in the basin for certain model parameters (e.g. low water table amplitude and heat flux) and is negligible for others (e.g. high water table amplitude and heat flux). It is therefore a suitable transition value. Reviewer 2 recommended that the ranges used in the synthetic parameter analysis should be justified and referenced, so this has been done in the revised manuscript, together with the value of the salt concentration chosen for the bottom boundary.
Unfortunately, in the case of the BTK real hydrogeological model, there is no hydrogeological/geophysical/geochemical evidence of the salinity of the basement, so we chose the value of c_b=35 g l^{-1} to reconcile with the initial value (sedimentation in a marine environment (Mádl-Szőnyi et al., 2019)). At the same time, we also investigated how the evolution of the system is affected by the reduction of the basement salinity through diffusion. For this purpose, we defined an impermeable layer under the BTK model (between z=5 and 6 km asl) and imposed boundary conditions at the bottom of this layer. The simulation results are published in the Supplementary material, and the main conclusions of the results are incorporated in the Discussion section of the manuscript.

- **Boundary Condition Dominance in Figure 2**

Any boundary condition — whether it is a lateral boundary condition on the flow or a lower boundary condition on the salt concentration — affects the solution, i.e. the behaviour of the complex system. To address this question, we studied how the appearance and physical character of the thermohaline dome beneath the discharge zone are influenced by the no-flow vertical boundary condition. For this purpose, two unit basins were conjoined at the discharge zone, so the vertical boundary at the thermohaline dome was eliminated.
For the synthetic base model, the simulation was carried out in the doubled model domain, where the dome of saline, warm and aged water still formed in the middle part of the model, beneath the discharge zone, in which intense thermohaline convection was developed. The thermohaline dome, separated from the topography-driven flow regime on both sides by dynamic boundaries, was slightly weakened in its physical parameters (relative area, temperature, salt concentration and water age decreased by 4%, 9%, 12% and 21%, resp.), but the character of the flow was fully consistent with the flow/temperature/salinity/water age pattern developed in the unit half-basin. Thus, the behaviour of the topothermohaline system observed in the synthetic simulation series — thermohaline dome beneath the discharge zone — is clearly not a consequence of the lateral boundary condition. The results of the simulation are detailed in the Supplementary material, and the main conclusions are included in the Discussion section of the manuscript.

- **Implementation of Faults in BTK Model**

In this study, we have not investigated the role of the conduit/barrier faults. The faults shown in Figures 10 and 11 only separate the individual geometric units without any specific physical parameters. However, Szijártó et al. (2021) studied the role of conduit faults in the 'topothermal model' of the BTK system and found that they can influence the temperature distribution and the flow field mainly locally. If conduit faults were present in the environment of a high-temperature reservoir, they could, in theory, cause local anomalies both in temperature and salinity, but such surface manifestations do not exist in this particular hydrogeological environment. Only at the margin of the confined and unconfined karst, along the Danube River, the occurrence of springs with different temperatures, chemical composition and yields can be seen even near each other, as already mentioned in the Discussion of the manuscript. To clarify the potential role of faults, a separate paragraph has been dedicated to this point in the Discussion.

- **BTK Model – Validation Against Observed Data:**

The primary aim of our study was to visualize the phenomenon of topothermohaline convection and to quantify the dynamics of the complex hydrogeophysical system. At the same time, we intended to demonstrate the phenomenon in a real hydrogeological field where both topography-driven forced convection and free thermohaline convection can be present. Therefore, we chose the Buda Thermal Karst system. We would like to emphasize that the study is not a case study, so — in our opinion — a comprehensive comparative quantitative analysis between the numerical model and the real system would be beyond the scope of the manuscript. These case-specific synthesising studies have already been accomplished (e.g. Mádlné Szőnyi et al, 2018; Mádl-Szőnyi et al., 2019; Mádl-Szőnyi, 2019). Therefore, we deliberately focused only on the phenomena identified within the conceptual model framework.

On the other hand, this comment of the reviewer is fully understandable, so as a compromise, in addition to the previously reported data (temperature and discharge rate of springs, water age data), we have included new data (salinity of water samples from wells) and general observations from temperature-elevation profiles in the Discussion as a validation. We are hopeful that this effort, complemented by comparison of the BTK system with other topothermohaline systems and other possible systems where topothermohaline convection may be important, will meet the reviewer's expectations.

Furthermore, minor stylistic and grammatical errors have been corrected in the revised manuscript, which — at the request of the editor — has not been uploaded at this stage of the review.

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