We greatly appreciate the editor and referee for the valuable comments. Now, the responses to each of the comments are listed below.

Response to Reviewer 3

Point: I find it difficult to identify the novelty of this paper. I see no novelty compared to for example the review study, co-authored by Cui (10.1016/j.rser.2018.05.063) or the recent publication, including validation by Laferierre et al (10.1016/j.geothermics.2019.101788).

My key comment is that the authors should pinpoint the novelty more clearly. If the novelty cannot be identified more clearly, then I would reject the paper. At least a major revision is required.

Response: We have read this reference carefully (A comprehensive review on 2D and 3D models of vertical ground heat exchangers). In this work, the two-dimensional heat transfer numerical models of 6 types of BHE and the three-dimensional heat transfer numerical models of 4 types of BHE are introduced, and the applicable scope, advantages and disadvantages of the two-dimensional model and the three-dimensional model are compared. Finally, the three-dimensional model can be considered more uncertain factors and the model is more accurate, which can analyze various influencing factors of the buried pipe in the heat exchange process.

The research directions of the two papers are different. One is to review and compare the 2D model and the 3D model. The other is to study the change law of shallow geothermal field from heat interaction radius, the horizontal and vertical distribution of ground temperature, groundwater flow, backfill material and thermal equilibrium.

In section 7 (Important observations and recommendations for future research) of the literature, it is mentioned that the following areas should be paid attention to in the development process of GSHP.

1.The most current simulation approaches have never considered the effect of the groundwater movement on the performance of the BHE system, where the thermal interaction is greatly sensitive to the BHE number, depth and spacing. Hence, future research should concentrate on this aspect.

2.The dynamic soil surface temperature should not be assumed as a constant value or an adiabatic boundary value owing to many complex procedures and interactions taking place within the nearby surface. In other words, a precise numerical model must consider the effects of the wind speed, ambient temperature, solar radiation, cloud cover, relative humidity, rainfall, snow cover and surface reflectivity.

3.The computer programs should be verified through the experimental data and a comprehensive evaluation is extremely required to study their applicability for academic and engineering practices.

The innovational three points mentioned above are the factors that should be paid attention to in the numerical simulation of heat transfer process of BHE. In my paper, the innovations are as follows:

A three-dimensional model of fluid flow combined with heat transfer considering groundwater movement, backfill materials and ambient temperature conditions is established. In the model, the hydraulic gradient is 5/1000 and groundwater flows from south to north. Specific information is mentioned in Lines 190 to 195. Furthermore, the analysis of the influence of hydraulic gradient on heat exchange is conducted. Specific information is mentioned in Lines 302 to 311.

The analysis of the influence of backfill material on heat exchange is conducted by combining actual project and numerical simulation. In the project, the backfill material for K2 borehole is sand and its thermal conductivity is 1.1 W/(m*K) by laboratory test. The backfill material for K3 borehole is cement mortar and its thermal conductivity is 1.76 W/(m*K) by laboratory test. The backfill material for K4 borehole is the mixture of sand and barite powder and its thermal conductivity is 2.2 W/(m*K) by laboratory test. It can be seen that outlet temperature of the buried pipe for K2 borehole is the highest in summer working condition and outlet temperature of the buried pipe for K4 borehole is the lowest in summer working condition. Within a certain range, as the thermal conductivity of backfill material increases, the outlet temperature of buried pipe decreases gradually. It is concluded that backfill material with relatively high thermal conductivity facilitates heat exchange between buried pipe and surrounding formation. By comparison, the mixture of sand and barite powder is recognized as a more efficient and economical backfill material.

In the model, set the top boundary as a variable ambient temperature for ten years' simulation according to the data of local weather station and not set as heat insulation or constant temperature.

The analysis of the thermal interaction is conducted by probe function. It is of great significance for practical engineering in mountainous area with similar formation conditions.

Based on the advantage of 3D model, the change of ground temperature in horizontal and vertical directions is analyzed. Specific information is mentioned in Lines 360 to 395.

According to the calculation of thermal equilibrium by thermal storage method from

Technical Regulations for Shallow Geothermal Energy Investigation and Evaluation. The shallow geothermal field is analyzed from a new point of view. Specific information is mentioned in Lines 416 to 438.

Fortunately, we are studying the heat transfer process of U-shaped tube, coaxial tube and coaxial tube with turbulator. Meanwhile, we are carrying out practical projects. It can be concluded that the heat exchange performance of coaxial tube with turbulator is better than U-shaped tube and coaxial tube.

We have read this reference carefully (Development and validation of a full-time-scale semi-analytical model for the short- and long-term simulation of vertical geothermal bore fields). This paper presents the development and the validation of a semi-analytical bore field simulation model for short and long time scales. The principle of heat transfer is introduced by borehole model and ground model. In long-term experimental validation, borehole wall temperature in a sand box model is validated with simulated temperature. In short-term experimental validation, outlet an inlet fluid temperature in a sandbox experiment is validated with simulated temperature. Obviously, the sandbox model is an ideal model that is not exactly the same as the actual situation. Moreover, it is a difficult problem how to apply the experimental results of sandbox model to practical engineering through equivalent principle.

In 3.4 section of literature (Comparison with monitored field data of a Belgian office), on the one hand, the thermal response test (TRT) is not carried out in the experimental site. On the other hand, the ground temperature gradient measurement is not carried out but the assumption. It is not a reasonable way to verify the model.

However, in situ thermal response tests of three boreholes were carried out for our project and the simulated value is agreed with well the measured value. Furthermore, we measured the ground temperature in three boreholes, so it can provide an accurate initial value for the model. What's more, the thermal conductivity of rock, soil and grouting material were measured in the laboratory.