We thank both reviewers and the editor for their insightful and constructive comments. We have listed the comments made by the reviewers and our answers here below. We have quoted the remarks in italics, and have provided the answers in normal font.

1 Reviewer 1

The comments made by Reviewer 1 did not lead to any changes in the manuscript. For a detailed answer to the comments we refer to the discussion forum.

2 Reviewer 2

- General comments.
  - *The title of the paper "Advantages of Analytically Computing the Ground Heat Flux in Land Surface Models" does not seem to be delivered on. While the method the authors proposed may very well be valid, I do not see from the results that the analytical solution is better, especially since there is no comparison of the numerical solution or a conventional model to the observed values. I would prefer a more neutral title as well as a figure comparing both the analytical and numerical fluxes to the observed data (both time-series and x-y plot).*

    We are not really making the point that the analytical solution is better or worse. In the paper we have provided an x-y plot for a spatial resolution of 1 cm, for both the numerical and the analytical solutions. In the online discussion, we show time series plots, comparing the modeled ground heat fluxes to the observations, for the four different spatial resolutions. In all these plots one can see that there is not much difference between all these model results.

    This can be explained by the calibration. More specifically, the model parameters have been calibrated so the model simulations match the observations. It can thus be expected that in all cases the model performance will be relatively similar.

    We are making the point that, when using analytical solutions, the model will provide **more physically consistent results**. This is really the overall conclusion of the paper. In other words, the obtained thermal parameters no longer depend on the spatial resolution of the model. When using a numerical solution, the thermal parameters very strongly depend on the spatial resolution. This is physically not consistent, and these parameters should not be related to the spatial resolution of the model.

Based on this reasoning, at this point, we suggest not to alter the title of the paper. If it is deemed that we should change the title, we are certainly willing to do so.

- Specific comments.
  - *P4 18-21: "Of all the parameters affected by the resolution, the parameter that shows the largest variation in values is the thermal conductivity, with the value at $\triangle z$=0.1 m more than 4 times the value at $\triangle z$=0.01 m. No other parameter shows this variation."*
    → After reading the subsequent explanation. I can see, why for the purpose of this model this may be the case. However, I disagree with the statement that a physical interpretation of the soil heat conductivity is impossible.

    An observed value of the soil thermal conductivity will not depend on the spatial resolution that the model uses. Since the value of thermal conductivity used in the model depends on the spatial resolution of the model (i.e., $\triangle z$), this parameter loses its physical meaning.

    What would be the reason for the changes in the other values?

    This is simply equifinality. Since we have more parameters than observations and the model is nonlinear, different parameter combinations can result in similar model performances.
  - *P7: 12-15: "A pooled variance t-test with 95% confidence showed that all parameter values obtained with the analytical solution are not significantly different from the parameter values obtained with the numerical solution, with the exception of the objective function value and the heat capacity for all spatial resolutions, and the thermal conductivity for a spatial resolution of 0.01 and 0.1 m."*
    → Please reformulate this sentence. In my opinion this sentence obfuscates the fact that there are large differences in the parameters.

    We do not agree with the statement that this sentence obfuscates the fact that there are large differences in the parameters. It actually states that there are differences in the three parameters mentioned. This conclusion is obtained in a statistically correct manner. We do agree with the remark that we should rephrase it. We suggest to do this as follows:

"A pooled variance t-test with 95% confidence was applied to the parameter values obtained with the analytical and numerical solutions, to investigate which parameters are significantly different. This test showed that the only parameters that are significantly different are the objective function value and the heat capacity for all spatial resolutions, and the thermal conductivity for a spatial resolution of 0.01 and 0.1 m."

We have made this change on page 7, line 12-15.

- *P8 6-7: "The solution derived in this paper does not allow for temporally varying soil thermal properties, ..."* $\rightarrow$ *given the fact that soil thermal properties are highly dependent on water content, which varies in time. Does this not unduly limit the proposed method.*

  The answer to this question is yes and no. For the model that is used, with temporally constant parameters, the method can certainly be used. The model and the method allow us to draw the conclusions that we draw in the paper, which are certainly valid for more complex models as well. If we were to use this method in a real land surface model, we would need a solution with temporally variable parameters. Some general solutions already exist, but these are not straightforward to be coupled to land surface models. The derivation of an analytical solution with variable parameters is not straightforward either.

- *eq3 and others: consider* z_t *with* $z_{u(pper)}$ *in order to avoid confusion with* t *for time*

  This is a great suggestion that we have implemented in the new version of the paper.

- *Table 3: Depending on the resolution of the model, the parameters of the model seem to change widely based on the optimization algorithm. It is my concern that results may be a bit arbitrary if very different combinations of the model parameters lead to virtually the same results. I am especially concerned that analytical solution and numerical solution at the same resolution have very different parameters. Assuming that these parameters have a real world manifestation , then they should be constant across runs.*

In Sections 5 and 7 of the paper we discuss this. There are a number of parameters that are statistically not dependent on the spatial resolution. These are the roughness lengths, the zero plane displacement height, the surface resistance, and the surface albedo. This is because these parameters appear in equations that do not depend on the model spatial resolution. For all the other parameters, there is a significant dependence on the spatial resolution, because they appear in equations that depend on this (either the Richards equation or the heat conduction equation). The results in Table 3 thus make very good sense. In Section 7 we provide the results of a test investigating which parameters are different when obtained with the analytical and numerical solutions. As can be expected, it is the thermal conductivity and the heat capacity, because these parameters appear in the heat conduction equation.

– *Table 4: There appears to be a large difference in the observed and modeled G (4 vs. 0.35). Why is the modeled mean G off by so much. Also, while the RMSE values between the different model resolutions are similar to each other, at some instances larger resolutions have smaller RMSE. Could the authors comment on this.*

  A difference of less than 4 is a relatively small difference, as the ground heat flux values go up to 80 Wm^{-2}. The RMSE values are also very similar for different scales. We do not think it is necessary to add any further comments on this in the text.

– *Figure 2+5. I cannot distinguish the lines without zooming into the PDF. Since there is not charge for color figures. Please consider either using colered lines or at least to make lines for distinguishable. Figure 3. Assuming that the crosses and the line perfectly match (I cannot see the lines), please either use a grey/colored line on top of the crosses.*

  In Figure 2 the model simulations are all very close to each other, so using colored lines will not distinguish between the lines either. We have added a line in the caption explaining that the model simulations very strongly overlap, avoiding confusion. If it is deemed necessary to use colors, we are certainly willing to do so.
  Figure 5 is essentially a scatterplot, so adding colors to this plot will probably not add value. Again, we are willing to use colors if this would be necessary.
  For Figure 3, we have clarified the overlapping of the lines and crosses in the caption.

- *Figure 6 and associated text. Please specify, which analytical solution is being displayed. Why does the vertical resolution make a difference in the analytical solution?*

  We have specified in the caption that Equation A31 is being used. We applied the model with the analytical solution for four different spatial resolutions, and for this reason we specified which resolution we used. It should be noted that the analytical solution only refers to the heat conduction equation, but the Richards equation is still solved numerically, and can thus have different spatial resolutions.

- *eq A1: I am also confused with eq. A1. I understand that downward water movement constitutes a heat transfer. However eq. A1 does not contain the heat capacity of water but only the soil heat capacity. This confuses me. Please clarify.*

  Equation A1 estimates the temperature of the soil-water medium, and C is heat capacity of this medium. The term defining the advection of heat (i.e., $vC\partial T/\partial z$) should only include the heat capacity of water. However, we included this term because it facilitates the inversion of the Laplace transform, but for the analysis in the paper we use the limit case of the heat conduction equation without advection (i.e. Equations A30 and A31).