General Comments

This manuscript uses the surface energy and moisture flux model ForHyM2 to investigate the impacts of atmospheric climate change on surface and subsurface water temperatures in a small catchment in New Brunswick. While the model is relatively simple and is empirically-based, the results are of general interest despite their site-specific nature, and provide an excellent lead-in to the anticipated 'future physically-based' flow and transport modelling.

Thank you for your positive comments and interest in this contribution.

It is important for the authors to note that due to the empirical nature of the model the results are site specific, and while some general ideas of how groundwater and surface water temperature may be impacted by climate change can be gleaned from the results, no specific process-based conclusions can be made.

This is a valid point, and we will be more explicit about the site-specific nature of our study (see our responses to you specific comments below). However, we would like to point out that all site-based hydrological/hydrogeological model results are site specific regardless of the characteristic of the model (empirical vs. process-oriented). Furthermore, our modeling approach is not entirely empirical. The first step in our modeling sequence was to use the physically-based ForHyM2 model to translate the downscaled meteorological data into surface temperature. This modeling step accounted for climate dependency on the lower atmosphere-surface temperature relationship. Indeed, the lower atmosphere-surface thermal exchange would be poorly represented by an empirical model due to, for example, changes in the duration and thickness of winter snowpack.

Our function for translating surface temperature to groundwater temperature is certainly empirical, which is acknowledged in the manuscript, but its basic form was derived from physical processes as we discuss on P3294, L13-P3295, L2. Its application to translate the surface temperature into depth-dependent groundwater temperature thus seems reasonable.

Overall, the manuscript is scientifically sound, generally well-written and is reasonably easy to read. However, a significant decrease in the use of acronyms would greatly increase the readability of this manuscript. There are several scientific and grammatical issues that need to be addressed before the manuscript is finalized. These issues are addressed in the specific comments below.

Thank you for your positive comments above. Several of the acronyms are commonly employed in surface temperature or shallow subsurface temperature studies. These include: GCM, RCM, AT, and GST. Admittedly, other acronyms that we employed are not always utilised. We will therefore remove the follow acronyms: MAGST, MAAT, GWT, and STS.

Specific Comments

P3284 L26-27: Either remove this last sentence, or give the reader information of the ecological significance. Not appropriate in an abstract to say that something 'will be discussed'.

This sentence will be removed from the revised abstract.

P3288 L6-12: Answering these questions with the methods provided are not general answers, they are specific for the site. This should be acknowledged; as it is written it appears the authors will make general assumptions from the empirical model developed for this site.

The original wording states that the 'questions will be answered in reference to a small forested catchment with available field data… and in which cold groundwater discharge has been observed to provide thermal refugia for salmonids'. Thus, some attempt was made in our original HESSD submission to acknowledge the limitations of our findings. However, we will include an additional sentence that more explicitly acknowledges that our findings are primarily relevant for our study location.

P3291 L12: Why was this future time period used as opposed to that immediately following the reference period? I have no doubt there are reasons, they should just be given to the reader.

This period was chosen due to the availability of downscaled climate data. This study is part of a broader collaborative initiative that is investigating salmonid thermal refugia and their sensitivity to climate change. The climate data were obtained from collaborating climatologists. We will state this explicitly in the revision.

P3282 L19-24: For a simplified empirical model, questions arise at this point as to the ability for it to represent future conditions. Stationarity is a big concern in all climate change related research, especially in those not physically-based. This is somewhat addressed at the end of the manuscript (Limitations of the approach), but perhaps a detailed explanation as to why this approach would still be suitable is appropriate here.

This page-line reference is not in the HESSD paper. Do you refer to P3294, L19-24? We do acknowledge the limitations of this approach in our methods sections in addition to the conclusion. On P3295, L3-10, we describe how similar models are used to project future surface water temperature, and how our approach is actually more insightful.

Furthermore, the GST predictions do not suffer from assumptions of stationarity. (Stationarity may be a concern for the statistical climate downscaling processes, but such a discussion would not be suitable for the present contribution. Climatologists often debate the relative merits of dynamical vs. statistical downscaling). The physical basis for the form of the empirical GST-groundwater temperatures transfer function has been addressed above.

P3298 L22-25: Would these errors not also arise from the expected increase in 'extreme' precipitation events due to climate change (increased intense rain events, and thus increased floods)?

The errors that are mentioned in these lines refer to errors arising in the empirical function applied for the present climate. If we interpret you correctly, you are suggesting that these errors could also affect the ability of the model to simulate future groundwater temperature and should thereby be included in our limitations discussion (P3302, L4-10). This basic notion is correct and will be added to our discussion of the potential climate change-dependent nature of the B parameter.

P3302 L1-2: This sentence is again, quite site specific. Saturation of the subsurface can play a very important role in the distribution of energy between the atmosphere surface-subsurface, and would be impacted by changes in precipitation patterns due to climate change.

Again we note that ForHyM2, which is process-oriented, properly accounts for the relationship between climate change/precipitation patterns and the energy exchange between the lower atmosphere and the surface (and shallow subsurface saturation). Thus these atmosphere-surface relationships, which are climate dependent, have been simulated in our approach.

In could be argued that the soil diffusivity is dependent on saturation and consequently climate change. This will have very little impact at our site because the groundwater table is so shallow. However, a caveat will be placed in this paragraph to acknowledge that the subsurface thermal diffusivity may be climate-dependent at other sites that have deeper unsaturated zones.

Section 6: Emphasis on the site specific nature of these results. As it stands, it reads as though they are general conclusions.

A short statement will be included in our concluding paragraphs to acknowledge the site-specific characteristic of this study.

Technical Corrections

P3291 L22: Just EC, 2010; there is no EC 2010b in the reference list.

P3292 L9: No EC 2010b reference in reference list, perhaps EC 2011?

Thank you for noting the errors in our references. We had updated the reference list without updating the citations. This will be fixed in the revision.

Figure 2: The arrow pointing up from 'Groundwater Flow' is a little confusing. Is this indicating upwards flow, or trying to show the horizon in which groundwater flow occurs?

It was intended to represent the horizon of groundwater flow. We admit this was confusing, and it will be adjusted to read “Surficial aquifer with groundwater flow”.