Response to Reviewer comments

Response to Reviewer 1

General Comments

The manuscript presents experimental data of soil physical and hydraulic properties along glacial moraines of different ages. These basic soil properties (texture, bulk density, porosity, organic carbon content, water retention and hydraulic conductivity) provided here are very useful because they are essential for any quantitative modelling of water and element balances of such soil ecosystems. I congratulate the authors for such a large effort and service for the scientific community. The data basically confirm the theoretically expected pedologic and soil structural development; however, since similar data in comparable quality are extremely rare and relatively difficult to obtain in reproducible way, so much the better are those of the current manuscript. I would also not be too disappointed about the problems with the description of the hydraulic conductivity functions based on the evaporation data. These data if made available maybe analysed in the future with other methods; it did not seem to me that it was the aim to do it in this data paper. Still, I have a few comments and suggestions for clarification, discussion, and possible improvements:

Response to General Comments

The authors would like to thank the reviewer for spending his/her time on this review and for making valuable comments to improve our manuscript. We are happy to see that our efforts and the data set are appreciated! We will address all comments and suggestions below.

1. The soil depth is defined related to the current soil surface. During the long times of development, the surface topography may have changed (erosion, colluviation) such that the surface-depth relation could be different at the different locations. This may affect the variability in space and time. Would it be possible, perhaps for future studies, to identify an alternative reference such as, for example, the depth to the intact parent material or other marker?

We agree with the uncertainties caused by defining the soil surface as the reference point. We agree that for example the depth to the intact parent material could be an alternate marker that excludes those uncertainties. However, we also believe that locating (and also reaching) the depth of intact parent material can often be difficult.

2. I missed a soil profile description or classification – even a simplified description of soil type and soil horizon characterization would increase the information content on conditions in the sampled soil depths.

We agree that some more information on soil type and soil horizon characterization would be helpful. We will further include some more information on elevation, slope, dominant vegetation, vegetation cover and soil type in form of a table. We will also update the site descriptions a follows:

We will include the following information in section 2.1.1 (Silicate parent material):

Page 5 Line 4: "Table 1 provides an overview of the main characteristics of the 4 moraines including elevation, slope, dominant vegetation, vegetation cover, and soil type [Maier et al., 2019, Musso et al. 2020]. The soil at the two youngest moraines was classified as a Hyperskelectic Leptosol. At the 3 000 years old moraine a Skelectic Cambisol and at the oldest moraine an Entic Podzol was found. Illustrations of the horizontal soil layers at each moraine can be found in Maier et al. (2019). The vegetation cover

differs significantly among the four age classes and was mapped in summer 2017 (Maier et al., 2019). The moraines are occasionally grazed by cows and sheep during the summer months, which we prevented during our study by the installation of fences. Whereas the vegetation cover at the oldest moraine was dominated by a variety of prostrate shrubs, small trees and several grasses, the 3 000-year-old moraine has mainly a grassland cover with fern, mosses, sedges and forbs. The 160-year-old moraine was dominated by grasses, lichen, forbs, and shrubs. The vegetation cover of the youngest moraine was sparse with mainly grass, moss, forbs, and a few shrubs."

We will update the text in section 2.1.2 (Calcareous parent material) line 18-22 to:

"*The four selected moraines were dated by Musso et al. (2019) based on historical maps and the radiocarbon method. The youngest moraine is 110 years old and is located at 2200 m a.s.l. The three other moraines are 160, 4 900, and 13 500 years old and located at an elevation of roughly 2030 m a.s.l. (see Fig. 1). An overview of the main characteristics of the 4 moraines including elevation, slope, dominant vegetation, vegetation cover, and soil type [Maier et al., 2019, Musso et al., 2019, Musso et al., 2020] is provided in Table 1. The soil at the two youngest moraines was classified as a Hyperskeletic Leptosol and at the two oldest moraines as a Calcaric Skeletic Cambisol (Musso et al., 2019). The two oldest moraines were densely covered with grass, dwarf shrubs and sedge. The vegetation coverage of the two younger moraines was sparse with patches of grass and forbs at the 160-year-old moraine and patches of mostly mosses and lichens at the 110-year-old moraine."*

3. The particle-size analysis seems to be non-standard, so this could be described a bit more detailed. The sample preparation and dryness state (air, oven) of "Dry sieving", for example, could be defined, the samples should then not be aggregated in any form. Usually, the organic matter and the carbonates are destroyed before wet sieving, and dispersion agent is added. Of course, for the carbonaceous parent material, another method is needed and also the methods to distinguish between organic and inorganic carbon content complicate the analyses. The organic particles could also be water repellent.

   We agree, that the description of the method used for the particle size analysis could be described in more detail. We will add the description below to the revised manuscript.

   "For the grain size analysis, we used a combination of dry sieving (particles > 0.063 mm) and sedimentation analysis (particles < 0.063 mm) with the hydrometer method. Particles between 2 mm and 0.063 mm were classified as sand, between 0.063 mm and 0.002 mm as silt and < 0.002 mm as clay. Particles larger 0.063 mm were separated from the fine particles by wet sieving. They were then dried at 550 °C for combustion of organic matter prior to the dry sieving. Due to lab limitations organic matter removal from the fine particles was only possible by floating off the lighter fractions prior to the sedimentation analysis. 24 hours before sedimentation analysis, $Na_4P_2O_7$ was added as a dispersant to the sample solution to prevent coagulation of the particles. Particle size fractions were calculated as weight percentages of the fine earth (< 2 mm), thus excluding gravel and stones to avoid that single larger stones shift or dominate the distribution."

4. The discussion (Page 19) on problems with the evaporation method seems too detailed in comparison to other aspects; it shifts the focus too much towards critical evaluation of the application of this method.

   We agree and will shorten the text to:

"Out of the 60 soil samples taken at each moraine and analyzed by the method according to Schindler (1980), only 32 at S-PM and 41 at C-PM could be analyzed for the hydraulic conductivity curve according to the method by Peters and Durner (2008). Seven of the excluded soil samples at S-PM and two at C-PM could not be used because the installation of the second tensiometer into the sample was prevented by stones. The other excluded samples could not be evaluated, since during the evaporation experiment, the upper part of the sample dried out much faster than the lower part. An approximately linear profile of the soil matric potential within the sample can thus no longer be assumed. This poses a limitation of the method and is usually typical for soils with large pore sizes, such as sandy soils."

5. Overall, the text could be condensed a bit.

   We will reread the text thoroughly and will condense it wherever possible.

6. The use of the past tense and the present tense in the English text is not always consistent and should be checked.

   We agree and will correct the tense.