Response to Reviewer comments

Response to Reviewer 2

General Comments

The manuscript addresses relevant scientific questions within the scope of ESSD. The findings correspond to the previous researches on soil chronosequences, but go further including new, not studied well before, physical and hydraulic properties in the analysis. The manuscript well written, scientific methods and assumptions are valid and clearly outlined. I recommend the manuscript for publication after some minor revisions.

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 will address these comments and suggestions below.

1. The introduction gives the general view on the previous soil chronosequences studies, however the number of such studies is so large that it is not clear why the authors have chosen the papers they have referred. Please give a few words to explain the choice.

We agree that there is a large number of soil chronosequence studies. The chosen papers specifically deal with the investigation of soil physical and chemical changes along soil chronosequences. We thus give an exemplary overview of studies which are most comparable to our presented study. A full literature review is beyond the scope of our data presentation. We will add a sentence to clarify this.

2. The characteristics of the objects are very superficial – no topography and slope characteristics, but according to the Figure 1 they are important in understanding of soil features of the chosen chronosequences. The authors give the reference for the vegetation distribution but it is not characterized in the paper at all. The main criticism is related to the absence of the names of soil types under study. The description of soils is also absent. I recommend including the full characteristics of study objects in the supplementary data but soil type names should be included in the main text.

We agree that some more information on topography, slope characteristic, soil type and soil horizon characterization would be helpful and we will include this in the revised manuscript. We will include a table containing information on elevation, slope, dominant vegetation, vegetation cover and soil type and update the site descriptions:

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 study objects are not CHRONOSEQUENCES but TOPOCHRONOSEQUENCES with essential difference of topographic locations of different ages. For example, the soil of 110 yrs will never have such characteristics as the soil of 13,5 kys, as its drainage conditions are initially different. Surely, it is almost impossible to find an ideal chronosequence, especially in mountainous conditions. However, it is worth to explain it clear in the Discussion.

We agree on the need to discuss the limitation of the chronosequence approach and will include the following into the text:

"The space for time substitution approach assumes that a sequence of sites (e.g. moraines) with similar site characteristics like topography, climate and parent material can be treated as a chronosequence. It is well known that the application of this chronosequence concept has some limitations. The assumption that time is the only factor affecting soil development in a spatial sequence of soils is rarely valid, but the only option for a detailed historical reconstruction of the soil development at a particular location (Phillips 2015). We therefore have to assume that differences in topography and elevation among the selected moraines only lead to moderate differences in soil hydrologic conditions. However, we made sure that slopes of the three selected plots per moraine were in a similar range. The plots at the silicate parent material range in slope from 18 to 34° with the majority of plots between 20 and 30°. The maximum elevation difference between the lowest and the highest plot is 108 m. At the calcareous site the slopes range from 27 to 44°, also with the majority of plots ranging between 20 and 30°. Here, three out of four moraines are at almost the same elevation. The elevation difference to the youngest moraine is 170 m."