

Interactive comment on “Arctic soil development on a series of marine terraces on Central Spitsbergen, Svalbard: a combined geochronology, fieldwork and modelling approach” by W. M. van der Meij et al.

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Dear referee,

Thank you for the time put into reading and reviewing our manuscript. Below we provide our response.

General remarks The paper should be revised by an English speaking person. Some key phrases during the paper should be more supported by references.

C814

RESPONSE: We have let an experienced native English speaker review the level of English in the final manuscript.

Abstract The abstract is a little confused and also a bit long.

RESPONSE: We have reformulated and shortened the abstract.

Introduction Page 1348 Line 20: Difference of the properties of the soils is not only attributed to age. Please rephrase. Line 20 to 23: Support this part with a reference.

RESPONSE: Nuances to this sentence are made in the next sentence, where we discuss that variation in other soil forming factors is equal for all soils in the study area. We have rephrased these sentences to: “In chronosequences, the only soil forming factor that is significantly different for all soils is time. Variation in the other soil forming factors, i.e. landscape position, climate, lithology and organisms, is assumed equal for all soils in the study area. Consequently, variation in soil properties can be mainly attributed to the age of the soils (Vreeken, 1975).”.

Page 1349 Line 5 to 20: Support this part with more references.

RESPONSE: We have included more references on the use of marine terraces as chronosequences.

Page 1356 Line 15: Refer to the method used for grain size classes.

RESPONSE: The method for determining grain size classes is dry sieving, as is mentioned on Page 1355, L. 26-27.

Line 20 to 22: Please rephrase.

RESPONSE: Rephrased to: “Geomorphic processes are oriented laterally and only affect the top soil layer. Pedogenic processes are oriented vertically and alter material or transport material from one soil layer to another.”

Page 1360 Line 15: Why only use one of the processes?

C815

RESPONSE: Here we intended to say that only one process is calibrated using the data. However, the same data were used to validate the model results. The model results are the result of several processes. Therefore the calibrated parameter does not correspond 1 to 1 on the model results. As this is a logical consequence of modelling and because the meaning of the sentence was unclear, we have removed this sentence.

Page 1364 Line 21 to 24: Please rephrase.

RESPONSE: Rephrased to: "The fitted uplift curve suggests that the youngest terrace is around 1500 years old. That could indicate that uplift has stagnated or reversed, leading to flooding of lower lying terraces, as is also suggested by Long et al. (2012) and (Strzelecki, 2012). This corresponds to renewed glacier growth in response to a cooler climate starting 3000 years ago, which eventually led to the Little Ice Age (Rachlewicz et al., 2013; Svendsen and Mangerud, 1997)."

Page 1365 Line 3 to 9: This part need a better explanation and support with references.

RESPONSE: We have better explained the methodological comparison between OSL and radiocarbon dating and supported it with references.

Page 1368 Line 6 to 11: This part need a better explanation and support with references.

RESPONSE: We have now elaborated on the effects of dissolution on the particle size distribution of the soil.

Page 1367 and 1368 (5.3 Soil Formation): SEM analysis would have been very useful for this paper, especially for the understanding of the weathering rates. Also, detailed profiles of the marine terraces, organic matter and silt content would also serve as a good support.

RESPONSE: We agree with the reviewer that SEM analysis would have been a valuable contribution for better understanding the weathering rates. However, as this research is an exploratory study on soil formation on a landscape scale, detailed analyses such as SEM and more detailed profile descriptions were beyond the scope of this study. We mentioned these methods in the Discussion, as a consideration for future studies.

Page 1370 (5.4) To better explain the temporal interaction, a Table comparing your dates and from surrounding areas would support your results.

RESPONSE: We thank the reviewer for this suggestion, but comparing absolute ages from our study with those for surrounding areas may not produce useful information if they are not placed into context. It can also prove difficult for methodological reasons, because older radiocarbon dates are often not calibrated or corrected for the marine reservoir effect and therefore not directly comparable to OSL dates. A comparison of our uplift curve with other curves is more meaningful. We used our datings for reconstructing an uplift-curve. This was compared with surrounding uplift curves. As suggested by Eric Brevik (Short Comment 685 on interactive discussion of this paper), we constructed a new uplift curve, which better matches curves found in studies done in surrounding areas.

Conclusion Page 1371, line 25-page 1372, line 1 to 3: It is not clear the signs of the physical and chemical weathering. A quartz grain analyses using SEM would support this conclusion.

RESPONSE: The signs of physical weathering refer to a decrease in the coarse fraction. Evidence of chemical weathering was derived from the presence of secondary carbonates on rocks in the soil. Together these processes affect the complete particle size distribution of the soil. SEM might indeed have supported this conclusion, but as mentioned earlier, this was outside the scope of this study. We rephrased this conclusion to: "The changes in soil properties of the gravelly soils on the marine terraces can be attributed to different soil forming processes, such as physical (frost action) and

chemical weathering (dissolution) and translocation of silt. Dissolution mainly occurs in A horizons developed in marine material. Translocation of silt occurs everywhere in the landscape, following the water flow.”.

Page 1372 Lines 4 to 7: OSL is a good dating technique, but you only have 3 dates that could not be enough. You should compare your dates, with others from nearby areas.

RESPONSE: Our three dates support earlier radiocarbon datings on the same terraces. We agree with the reviewer that 3 dates are not sufficient to draw hard conclusions, and therefore we weakened the conclusion to: “Optically Stimulated Luminescence (OSL) results support earlier radiocarbon dates from the area. Moreover, an uplift curve constructed based on both types of dates concurs with a nearby uplift curve, indicating the potential of OSL for measuring uplift rates in this setting. Combining these datings with field observations enabled the calculation of process rates using field observations.”

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References:

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