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Interactive comment on "Investigation of a deep ice core from the Elbrus Western Plateau, the Caucasus, Russia" *by* V. Mikhalenko et al.

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Authors express their gratitude to "Anonymous Referee #1" for the review and the proposed edition of the manuscript. Yes, indeed, we were not yet able to present the complete set of the obtained data, because some analysis required additional (and probably rather long) time to be finalized. On the other hand, we felt that the presented parts would be of interest to potential readers, can be used as the reference in the other papers to come, and therefore decided to publish what we already had.

"The manuscript (MS) presents 'an investigation' of a 182m deep ice core obtained from the Mt Elbrus, in Caucasus, Russia. Essentially, the investigation consists in a dating of the upper 130 m of the ice core by layer counting based on water isotopes, ammonium, and succinic acid combined with a model age scale below 130m depth.

Furthermore, a density profile, a borehole temperature profile, and a radar sounding survey are presented and discussed in the MS. Many other records from the ice core are mentioned both in the abstract and in the main text but they are mostly not shown or applied in the MS." The "depths" in the paper were expressed in several ways (the real depth, the depth in ice equivalent and the depth in water equivalent), so it could be sometimes confusing. However, in our view such difference was required for the logic of the manuscript and for the further comparison with existent data from the literature. The actual "counted" age layers in ice equivalent corresponded to about 150 m of the "real" depth.

"The introduction of the MS is very long and detailed summarizing a vast variety of meteorological, geographical, and glaciological data from the Caucasus region. Most of this introduction material is not directly relevant for the ice core dating and presented ice core profiles, that in my view constitute the core results of the MS, but most of the introduction may be justified as a sort of background summary, since many of the cited references are written in Russian and will not be assessable to many readers of The Cryosphere." The introduction chapters took 8 pages (from 48 in TCD format) and we did discuss several times on what should be in and what should be not. Both Russian and French team members agreed to keep most of information provided now. As You mentioned – such a review had been never published in English before and might be useful for further work and citations.

"The ice core dating is convincing and supported by the independent reference horizons of 1963 AD Tritium, 1912 AD Katmai, and volcanic spikes from around AD 1833-1840, none of which are, however, presented in the manuscript. I think it would be fair to ask the authors to show the data behind those horizons and how they align with the records applied for layer counting, as those horizons are essential for the validation of the chronology. As underlined in the MS, the mentioned but not shown records of the ice core potentially provide a most valuable regional archive of the last centuries and therefore a reliable dating is essential. The presented records are convincing and provide a rare example of an Alpine type ice core that is not disturbed by melt (as proven by the annual layer counting)." In the revised version we add Figure 10 showing Tritium measurements and the chemistry of snow layers attributed to the Katmai eruption. We also add a few words on the 1840-1833 AD layers. Following that we have updated section 3.3.6 as follows: "Dating based on annual layer counting of the chemical stratigraphy is in a fairly good agreement with the tritium 1963 time horizon that is located at the core depth of 50.7 m w.e. (dated at 1965 using the ammonium stratigraphy, Fig. 10a). In addition it fits very well with the dating achieved so far (i.e. core down to 106.7 m) on the base of the seasonal stratigraphy of the stable isotope profile. Whereas stable isotopes predict the year 1924 at a core depth of 106.7 m, the chemical stratigraphy leads to estimate the year 1926 in this depth. To anchor the depth age relation with further absolute time horizons, a first inspection of the sulfate profile was made in view to identify volcanic horizons as found in other northern hemisphere ice cores between 1912 (Katmai) and 1783 (Laki eruption) in Greenland (Legrand et al., 1997; Clausen et al., 1997) and at Colle Gnifetti (Bohleber 2008). However since the Elbrus is an in active volcanic crater, it is sometimes difficult to attribute a peak either to a well-known global eruption or to a local event. Furthermore, numerous sulphate peaks in the Elbrus ice core originate from terrestrial inputs as suggested by the presence of concomitant calcium peaks. So far, the Katmai eruption in 1912 could be clearly identified at 87.7 m w.e. (dated at 1911 using the ammonium stratigraphy) with several neighboured samples showing relatively high sulfate levels (up to 1200 ppb, i.e. 25 μEq L-1) compared to those seen in sulphate peaks generally present in summer layers of the early 20th century. Furthermore, as seen in Fig. 10b, in contrast to neighboured summer sulphate peaks located at 87.2, 87.4, 88.0, and 89.3 m w.e., that are alkaline (see Fig. 10b), the acidity of samples of the 87.7 m w.e. sulphate peak reaches 8 μEq L-1 at the bottom part of the sulphate peak. Furthermore, samples located of the top part of the 87.7 m w.e. sulfate peak remains neutral in spite of a large presence of calcium (similar to those seen in neighboured summer sulphate peaks). As seen in Figure 11 it appears that within one-year uncertainty this horizon is in excellent agreement with our

annual counting." Below 88 m w.e., we were still able to easily proceed annual counting down to 113 (1860), whereas further down the dating become more uncertain (see the blue line in Fig. 9). Below 88 m w.e., 7 significant potential volcano horizons can be suspected on the basis of the ionic balance and sulfate levels (not shown), from which however at least 1 are of local origin (as suggested by small stones with size of up to 1- 2 mm were found in the corresponding layer). Nevertheless, a series of 3 narrow spikes was located at 118-120 m w.e. (dated at around 1840-1833) among which two that are characterized by an increase of sulphate and acidity (up to 7.8 μEq L-1, not shown) may be related to the well-known eruptions observed in Greenland in a time distance of 2 years around 1840 (one of them being possibly due to the Coseguina eruption in 1835) (Legrand et al., 1997)."

Since Figure 10 reports on the calculated acidity of snow layers the text in section 3.3.1 we consistently updated as follows: For cations (Na+, K+, Mg2+, Ca2+, and NH4+), a Dionex ICS 1000 chromatograph equipped with a CS12 separator column was deployed. For anions, a Dionex 600 equipped with an AS11 separator column was used with an eluent mixture made on the base of H2O, NaOH at 2.5 and 100 mM and CH3OH. A gradient pump system allows determining inorganic species (F-, Cl−, NO3-, and SO42-) as well as short-chain monocarboxylates (denoted MonoAc-) and dicarboxylates (denoted DiAc2-). For all investigated species, ion chromatography and ice core decontamination blanks were found to be insignificant with respect to respective levels found in the ice core samples. As discussed in Sect. 3.3.5 the search of volcanic horizons in the Elbrus ice cores needs examination of the acidity (or alkalinity) of samples that can be evaluated by checking the ionic balance between anions and cations (concentrations being expressed in micro-equivalents per liter, μEq L-1): [H+] = ([F-] + [Cl-] + [NO3-] + [SO42-] + [MonoAc-] + [DiAc2-]) - ([Na+] + [K+] + [Mg2+] + [Ca2+] + [NH4+]) (4)

"The MS is mostly well written, well illustrated, and well referenced. Several sections, such as section 2.2, need to be proof read by the authors or a native English speaking person to correct a number of minor syntax and grammatical errors. In particular, the absence of the words 'the' and 'a' in several sentences is disturbing." We did our (joint) best to correct the errors and "the/a" in the text, so hope it is not disturbing now.

Specific comments: "Why does the isotope profile end at 106.7 m depth and is not extended to the deepest part of the ice core?" At the time we wrote the paper isotope data were only available down to 106.7 m depth (the new version of the figure is expressed in w.e. depth). We now finalized the isotopic analysis of the deeper part of the core but still decided not to present it is this paper. Fig. 7 is showing the comparison with other shallow cores data from the same drilling site and the amplitude of the isotope content variability. Below the amplitude is decreasing with depth, the smoothed profile shows some trends not only due to natural variability but also because of sampling resolution, samples density, ice layer thinning, etc. The isotope profile as the whole should be analysed in a separate paper where all the possible processes would be accounted for. Showing raw data in here can only confuse a reader. In addition, it has to be emphasized that for the dating purpose on which this paper focus, the chemical stratigraphy (based on ammonium and succinate) reported in this paper is expected to be more powerful than the isotope stratigraphy (the smoothing of seasonal variations with depth being more pronounced for water isotopes than for most of chemical species). All other "specific comments" are corrected in the text.

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