- The manuscript has been edited to implement all of the reviewers' comments, according to the replies reported below. Since the reviewers focused on the results and discussion section, that is the section that contains the majority of the revisions. Additionally, this section has been divided into 4 subsections (3H activity, 137Cs and 3H profile comparison, 137Cs and 3H total inventories, signal preservation in the adamello ice core) to better identify the presented results.
- The Marked up version of the manuscript contains in detail all the changes made to the manuscript. Additions to the text are reported in blue, while removed text is highlighted with a strikethrough font.

- The title of the manuscript has been changed from “Evidence of radionuclide fractionation due to meltwater percolation in a temperate glacier” to “Temporal markers in a temperate ice core: insights from 3H and 137Cs profiles in the Adamello glacier” as we think it better reflects the scope of this work.

- Figure 5 was removed as it was considered redundant and not necessary to the discussion.

- Point by point response from authors for RC1 for first version of the manuscript :

- Regarding the discussion about why we find a dust-rich layer approximately 1 meter below the misaligned 137Cs peak, our interpretation is that the notable dust peak below the 137Cs rich layer is independent and has not been influenced by 137Cs percolation. It is difficult to provide a hypothesis circa the conservation signal of the dust peak and its origin without having the complete dust profile of the ice core. In regards to why the 137Cs was not at least partly accumulated in the dust-rich layer this is a problem we cannot solve definitely with current data. Nonetheless we think that the key information contained in our data series is that in glaciers where heavy amount of melting is expected under current climate conditions, the 137Cs data is not to be considered as reliable as it always has been up to now in the ice core dating community. We will add some text to the article to further clarify this point:

“Dislocation of cesium particles inside the ice cores has undoubtedly happened, and the fact that a dust-rich layer with no cesium was found just below the cesium peak may be an indication that even a small amount of particulate (small enough to not be identified as a dust layer in the stratigraphy) can lead to a high cesium peak. On the other hand, a signal such as the tritium one which is a matrix signal, is more likely to either be conserved or be lost to melting, but we do not expect to observe relocation of the peak, and therefore we wish to recommend tritium analysis rather than cesium when a strong tie point is needed for datation.”

- In regards to misalignment between the two tritium peaks (high and low resolution), we consider the high-resolution series to be more reliable since the low-resolution series provides a mean value over a thicker portion of ice (as the samples are usually 50-60cm instead of 5-10 of the high-resolution series) and the high-resolution series has shown notable variations over limited ice thickness. Nonetheless the discrepancy between the activity values is inside the error bars as shown in Figure 4 and both series are not compatible with the depth of the 137Cs signal. It cannot be possible to have a relocation of the tritium signal following the same mechanism proposed for cesium because of the very nature of this signal, which is tied to the water molecule itself and not to particulate matter. No traces of refreezing at this depth in the ice core samples were found, thus if meltwater was present, it percolated down to lower levels leading eventually to signal loss of tritium but not to dislocation of the peak.

- Point by point response from authors for RC2 for first version of the manuscript

- To our knowledge, the shift between the 3H and 137Cs 1963 peak has been reported in a single study from Pinglot et al. (2003), more than 20 years ago and in a completely different context from the Alps. Our study is the first documentation of this phenomenon for an Alpine mountain glacier presenting fully temperate conditions. We think that despite the early single study, it is important to acknowledge the discrepancies we found between the radioactivity profile of the two considered radionuclides. It is common to find in literature chronological markers related to 137Cs or 3H, without really discussing the profiles or comparing them. The ice core community that works on mountain glaciers always assumes that those proxies are perfectly preserved in glacier ice, but, as we highlight, this is not the case, in particular at the time of climate change and global warming. Those signals can no longer be considered as fully reliable. We believe that this is an important message to share with glaciological community and we also believe that the scopes of this journal perfectly align with this.
- Regarding the established timescale we understand that additional comments may be needed and will add a paragraph to text as follows:

"*The established timescale may be slightly inaccurate regarding the layer counting between the 1986 and 1963 tie points, as it heavily relies on the implication that the 137Cs peak corresponded to the 1963 unaltered signal. The inaccuracy would introduce an additional error of 1 /2 years as the downward migration of the 137Cs signal is of only a couple of meters.*"

- We will also provide in the text an additional paragraph on the suitability of this glacier as paleoarchive by adding a summary of all glaciochemical published data available for this ice core, as pointed out by the reviewer:

"In Festi et al (2021) it is observed that peaks in pollen concentration and black carbon concentration with exceptional high values may represent multiple years condensed in one single layer as a result of negative mass balance years and enrichment of the impurities at the exposed surface. This poses an issue for annual layer counting. Despite this, due to the alignment of many palynomorphs and BC peaks, the seasonality of the signal seems to be preserved. On the contrary, in Festi et al (2021) the 210Pb profile did not show a clear exponential decrease in activity concentrations with increasing depth, as it is typically observed in glacier ice. 210Pb concentrations have shown in literature large fluctuations connected with dirt horizons (Gaggeler et al 1983) indicating that 210Pb may be transported with water, thus preventing a meaningful dating of temperate glaciers with this nuclide. 210Pb thus shows a behaviour in ice similar to what observed for cesium: these highly unsoluble elements remain bound to particulate matter and are prone to relocation and loss of signal when meltwater is present. Looking at 137Cs, by taking into account the highest 137Cs peak and comparing it to activity levels attributed to 1963 found at Colle Gnifetti (Eichler et al 2000), we found a loss of expected signal of more than 50%. On the other hand, looking at tritium the record seems to be mostly preserved at least for the period post 1960s (as the 1954 and 1958 peaks were not

detected in this ice core), because the shape of the tritium profile matches the tritium precipitation record and because comparing the total inventory, no loss in tritium activity is found; this is further confirmation about the better preservation of tritium compared to 137Cs. We thus believe that Adamello glacier can still function as a paleoclimate archive but to correctly interpret the information thereby contained, it is necessary to consider melting and disturbances processes affecting the climatic signals".

- Regarding the discussion about the misalignment between the peaks, the two tritium profiles (high and low resolution) have a difference of 1.5m but looking at activity values in the different samples between 29 and 31m it can be seen that they are well within the error bars; thus we can only say with no doubt that the 1963 deposition lies in this interval but we cannot pinpoint it without additional markers. Considering this, the displacement of 3H and 137Cs peaks lies in a range between 1.5 and 3 meters. Considering that the dating reported in Festi et al (2021) heavily relies on the implication that the 137Cs peak corresponds to 1963, it is difficult to say if the layer rich in mineral dust actually corresponds to 1959-1960, as the error on the dating would be much larger extending the possible dating range to the early 1950s. It is true that the Adamello ice core does not display radioactivity peaks that could be attributed to the pre 1963 era such as the 1954 and the 1958 peaks often reported in literature; the possibility of removal by percolation, especially since activities were much lower than 1963 and that additional time has passed (and therefore decay), leading to a much more faint signal which could easily be lost in presence of massive meltwater.
- In regards to why the 137Cs was not at least partly accumulated in the dust-rich layer, this is a problem we cannot solve definitely with current data. Nonetheless we think that the key information contained in our data series is that in glaciers where heavy amount of melting is expected under current climate conditions, the 137Cs data is not to be considered as reliable as it always has been up to now in the ice core dating community. We will add some text to the article to further clarify this point:

"Dislocation of cesium particles inside the ice cores has undoubtedly happened, and the fact that a dust-rich layer with no cesium was found just below the cesium peak may be an indication that even a small amount of particulate (small enough to not be identified as a dust layer in the stratigraphy) can lead to a high cesium peak. On the other hand, a signal such as the tritium one which is a matrix signal, is more likely to either be conserved or be lost to melting, but we do not expect to observe relocation of the peak, and therefore we wish to recommend tritium analysis rather than cesium when a strong tie point is needed for datation."