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Interactive comment on "Linking pollen deposition, snow accumulation and isotopic composition on the Alto dell'Ortles glacier (South Tyrol, Italy) for sub-seasonal dating of a firn temperate core" *by* Daniela Festi et al.

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Authors: We thank the reviewer for her/his comments and the time dedicated to our manuscript.

Referee #2: Dating of ice cores are challenging subject especially in non polar ice caps, where melting can influence the signal. Here the authors aim at using pollen to date a shallow firn core from the South Tyrol alps with a day to day resolution by comparing results from ice cores with nearby station data. It is an interesting approach to use pollen to date ice cores. In a previous paper (Festi, 2015) the authors used the

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same core and the same pollen data to date the record using PC and PCA methods to compare with airborne pollen samples from Solda. In this paper they use Jaccard similarities with the same airborne samples from Solda. They also in this paper use their highly resolved record to derive accumulation rates and compare those with a mass balance model, which as input use meteorological station data and move on to judge whether melt layers influence the pollen record.The main argument is based purely on the statistics, and the authors should consider how the sample depth may relate to the order of the samples. There is quite some indication of inverse orders, which to my opinion is not very well justified.

Authors, Changes in the manuscript: We now address specifically in sections 4.1 and 5.1, the inversions, clarifying their possible origin (wind erosion and redisposition, percolation, statistical artifact) and how this information contributes to the timescale.

Referee #2: However if accepting this kind of uncertainty in the dating of the samples, the pollen only arrive in spring/summer making the date of year dating only possible in spring/summer. This is not very clearly stated either.

Authors, Changes in manuscript: We now emphasize in paragraph 3.1. that the method can be applied in the spring and summer time since during winter and autumn there is no relevant pollen production in this region.

Referee #2 To me it is unclear that this paper brings much novelty to the already published paper by Festi (2015) in Journal of Glaciology.

Authors: The manuscript brings a very significant novelty in several respects :i) by presenting a new method to obtain a higher (sub-seasonal) resolution timescale based on pollen analyses; ii) by combining for the first time with highly interdisciplinary approach a pollen timescale with mass balance model (Eismodel); iii) by establishing the bases for a qualitative climate reconstruction of the ice cores dated by pollen. The manuscript includes a dedicated paragraph for each of these points. Changes in manuscript: We added a discussion section comparing our new results with those of Festi et al 2015

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to show the coherence and the improvement of the timescale: from seasonality to subseasonality.

Referee #2 however I would suggest the authors to largely rewrite the manuscript and focus more on the novel aspects (as compared to the Festi (2015) publication, eg. the comparison to the accumulation model and the water isotopes as well as to emphasize the uncertainties and justify the inversions of the dating better.

Authors: We add a new discussion paragraph outlining the improvements obtained in the timescale precision with the day-to-depth method in comparison to the principal components (PCs) method (Festi et al 2015). In this paragraph, we provide evidence that the new method considerably improves the timescale based on the PCs listing the critical points of the PC method and indicating how the new method overcomes them. Furthermore, we now better address and support uncertainties and accuracy for example by comparing Eismodel calculation with mass balance observations carried out in the period from 2009 to 2013 at the study site. We also better discuss inversions and emphasise their origin and implication for the timescale. Changes in manuscript: We added a new discussion paragraph (Timescale improvements). As suggested, we expanded in section 4.1 and 5.1 the parts regarding the inversions considering how the sample depth relates to the order of the samples as well as discussing the possible physical and statistical origin of the incongruence.

Referee #2: Section 3.1 Define the time of year in which you can make depth to day comparisons based on pollen.

Authors: It was already reported in the methods (March to October) but now it has been further emphasised and more clearly stated as a limit of the method. Changes in the manuscript: P4L1 According to the suggestion we stressed the time-window of the year for which it is possible to apply the method.

Referee #2: Section 4.1, line 6 expand the explanation about inversions. And consider also in Table 1 to explain this inversions, as the table otherwise is very confusing with

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dates going back and forth.

Authors: Thanks for the remark. In fact, inversions are quite interesting even if it is very hard to identify their origin. We decided to keep them and not to apply any adjustment because they can provide information about potential disturbance (wind redistribution and/or surface melt, as discussed in section 5.1) in the sequence. Changes in the manuscript: As suggested by the reviewer we added an explanation of the reason why we keep the inversions in section 4.1. Furthermore, a more detailed discussion of their origin and implications for the core chronology has been added in the discussion section 5.1.In the caption of table 1 we specify that the samples are listed in order of depth to avoid possible confusion, due to the inversions.

Referee #2: Section 4.1 in general should be more concise, it is very long and mainly lists the information from table 1.

Authors, Changes in the manuscript: We now reduced this section reporting synthetically the results of the pollen based timescale.

Referee #2: Section 4.1 eg. line 24, 31, 36 with more. The samples are 10 cm thick (?), how can layers be given in precision of cm, eg. 87 cm, 91 cm etc. These numbers should have uncertainties based on the sample sizes.

Authors: The depth is given in water equivalent and this is why depth are not merely 10-20-30 etc. We added a sentence also explaining that this is the “depth down” of the samples, meaning the value of the bottom depth of the sample.

Discussion paper Referee #2: Section 5.1 line 35/ Figure 3 (correlation figure). I am confused as it looks like you have more data in the correlation part of Figure 3 (eg. points during winter and autumn), where no points exists in the main part of figure 3 for pollen, where do these additional data stem from?

Authors: The graph contained also the winter and autumn points obtained by linear regression (paragraph 5.4 application of the pollen based timescale). We see how this

is confusing and therefore we changed it using only the spring and summer dates. Thanks for the remark. Changes in the manuscript: The graph has been updated as suggested.

Referee #2: Section 5.2 Discusses melt layers, however nowhere in any figures are the position of melt layers shown. Please add melt layers to relevant figures, eg. as vertical bars in Fig 2 (and Fig 3).

Authors, Changes in the manuscript: We now added melt layers as required in Fig 3 and ice lenses stratigraphy has been added to Fig 2.

Referee #2: Section 5.4 (figure 5) . Here you discuss the comparison to water isotopes. In the years 2007, 2008 and 2009 the water isotope data from april to July gets very steep, followed by a somewhat not steep slope down to the next winter. This seems like an effect of you having the pollen data very specifically dated in exactly those months. You suggest that those years are fine, but rather 2006 and 2005 are influenced by meltwater percolation from summer into the winter affecting the summer peak. This may very well be, but it does not explain the lack of similarities for the later years, where the steep slope to me looks very artificial. I would suggest you add some comments about the uncertainty of the dating, it could eg. be explained by later blooming of the pollen shifting the summer bloom and extending the dD peaks to have a more sinusoidal behavior as also observed in the Solda record of temperature.

Authors: We understand the reviewer's impression, however the steep slope in in the years 2007 and 2008 is due to the abundant snow accumulation in the springtime as it can be seen in Fig 3. The simulation of snow accumulation by Eismodel (Fig 3) points to a rapid increase in the snow cover resulting in the fact that several samples have similar deposition dates and cluster in a steep slope also in Fig 3.

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