Response to Referee #2 – cp-2019-94

We are thankful to the referee for their constructive comments on the article.
We will improve the manuscript clarity and detail the methods section following the guidelines provided by the referee#1.

Below are comments of the referee in blue, with our corresponding responses in black.

Kévin Fourteau on behalf of all co-authors

P3, Line15: Please write the units out the first time. 2 cm ice equivalent yr-1 (cm ie yr-1). No dot between cm and ie; otherwise it means cm times ice equivalent.
We will modify the units throughout the article, and remove the dots.

Please make it clear early in the manuscript that you prefer to use Antarctic high resolution data for comparison as they are not affected by the pole to pole gradient.
We will add to the text **P7L1**:
"When possible, we use high-accumulation records from ice cores drilled in Antarctica. Otherwise, in order to compare the high and low-accumulation records we need to estimate the methane inter-hemispheric gradient."

There are two continuous records from NEEM. Explain why you prefer to take the one you do or explain that it does not matter, does it?
We took the average values of the two instruments used by Chappellaz et al 2013. That being said, the two dataset are similar, and we could have also chosen one or the other.
We will add **P7L8**:
"Finally, the atmospheric reference used for the Vostok DO21 period is based on the NEEM CFA data published by Chappellaz et al (2013). Chappellaz et al (2013) propose two CFA records obtained with two different spectrometers. For this study, we used the average values of the two instruments"

I have a feeling on how the model works but the mathematical formulation on page 12 does not make sense. Unit wise that equation is definitely wrong. The model needs to be explained in depth and better before this manuscript is publishable.
Equation1 P12 is homogeneous, both the right and left hand side are expressed in m, the right hand side being kg m-3 / kg m-4. For clarity we will modify the way the unit of the densification rate is expressed in the article, using kg m-3 m-1 rather than kg m-4.

We will also remove the calcium-parametrization because it lacks robutness. The model is therefore now simply the depth-anomaly based version of the Fourteau et al (2017) model.

The manuscript has too many figures where records are also unnecessarily repeated. I suggest fewer graphs. The graphs also lack information on which record the Antarctic data is compared to. Please label Dansgaard-Oeschger events in the manuscript. When sections of the core are compared in the text, it would help to have them labeled in the graph.
We do not understand what repeated figures the referee is referring to. To gain space, we have merged both panels of figure 12.
We will label DO events in the figures, as well as the 8.2 ka event.
We will also add a table summarizing the studied ice core sections and their corresponding atmospheric reference.

Supplemental: S1 The depth scale seems to apply to Vostok not to NEEM. What section of the NEEM core is that? It is quite obvious that there is a gap in the original record that leads to the too much smoothed record. The conclusion about NEEM gas age is not supported in my opinion.

The depth scale is the one of Vostok. The mesured section is the DO21 of the main article.
We will modify the figure to use a gas age scale as the main x-axis. We will also add a second axis with the equivalent depth in the Vostok record.

The adjustment of the GAD is done solely where data are available, which means that in the DO21 Vostok case the adjustment is performed using the flanks of the first methane excursion and the large second excursion. The inability to find an age distribution that both matches the second excursion and the flanks of the first one is what leads us to think that the non-deconvoluted NEEM data cannot be used as an atmospheric scenario for the Vostok ice core. The missing data at the peak of the feature cannot explain why it is no possible to find an age distribution that matches the flanks of the feature.
We will clarify this point in the text **P15L19**:
"The GAD extraction procedure is designed to match the CFA record and the convoluted atmospheric reference only where CFA data are available. We thus do not have to extrapolate the CFA data within the gaps of the record. However, the absence of gaps in the records would have reduced the uncertainty of the estimated GADs, as the additional data would have provided more constraints on the GAD estimation."