Eric Wolff

First of all thank you very much for your constructive review.

This paper describes and presents a new model for computing ice core age scales. As the author explains, it has a very similar philosophy and methodology to the already-published DATICE model. The paper claims that it has some (especially computing) advantages compared to DATICE. It presents two examples of the use of the model, one confirming that it obtains similar results to DATICE for the same experiment, and the other producing a first age model for the Berkner Island core.
In general this is a solid piece of work that serves the community by making the code freely available in a (relatively) user-friendly format. Age modelling for ice cores is really important so there is no doubt the work is significant. However there are some issues that need to be dealt with:
a) Clarifying some of the equations and inputs
b) Making sure the code is clearly available on a formal and stable platform
c) The author's statements on the performance relative to DATICE should be discussed by DATICE people
d) There are some issues with the new Berkner age model that need to be explored.

Abstract, lines 2-10 consists of a single very long sentence, and one that seems more suited to the introduction than the abstract. I suggest the abstract needs more thought to ensure it truly explains what is new in this paper.

Abstract has been reworked:

Polar ice cores provide exceptional archives of past environmental conditions. The dating of ice cores and the estimation of the age scale uncertainty are essential to interpret the climate and environmental records that they contain. It is however a complex problem which involves different methods. Here, we present IceChrono1, a new probabilistic model integrating various sources of chronological information to produce a common and optimized chronology for several ice cores, as well as its uncertainty. IceChrono1 is based on the inversion of three quantities: the surface accumulation rate, the Lock-In Depth (LID) of air bubbles and the vertical thinning function. The chronological information integrated into the model are: models of the sedimentation process (accumulation of snow, densification of snow into ice and air trapping, ice flow), ice and air dated horizons, ice and air depth intervals with known durations, Δdepth observations (depth shift between synchronous events recorded in the ice and in the air) and finally air and ice stratigraphic links in between ice cores. The optimization is formulated as a least squares problem, implying that all densities of probabilities are assumed to be Gaussian. It is numerically solved using the Levenberg-Marquardt algorithm and a numerical evaluation of the model's Jacobian. IceChrono follows an approach similar to that of the Datice model which was recently used to produce the AICC2012 chronology for 4 Antarctic ice cores and 1 Greenland ice core. IceChrono1 provides improvements and simplifications with respect to Datice from the mathematical, numerical and programming point of views. The capabilities of IceChrono is demonstrated on a case study similar to the AICC2012 dating experiment. We find results similar to those of Datice, within a few centuries, which is a confirmation of both IceChrono and Datice codes. We also test new functionalities with respect to the original version of Datice: observations as ice intervals with known durations, correlated observations, observations as gas intervals with known durations and observations as mix ice-air stratigraphic links. IceChrono1 is freely available under the GPL v3 open source license.

Abstract, Line 10 “here I propose” seems a slightly awkward wording. Maybe “Here I present”.

Corrected.

Abstract, Line 15 “differences from” better than “differences on”.

Corrected.

Page 6813, line 25-27. It should also be mentioned here that this method requires assumptions, not always fully acknowledged, about synchroneity between changes of similar appearance in different archives.

You are right that such assumptions exists, however, this is not systematically the case. For example, the synchronization of a volcanic ash in an ice core to a dated lava flow can be based on the chemical signatures.
We prefer staying general and not mentioning this assumption in this particular section, but we mention this now in the discussion, in section 4.5. on the “current limitations of IceChrono and possible perspectives” .

Page 6814, line 25. AICC actually is presented as “Chronology” not “Chronologies”.

Corrected.

Section 2.1. There are several aspects I feel could be clearer here.

a) In line 7 “initial surface accumulation” – I don’t really follow the purpose of the word “initial”, surely each layer has only one accumulation rate, and the word “surface” already clarifies that you mean the one it had when it was laid down.

"surface" has been removed but we kept “initial”. “Surface accumulation rate” of a given ice particle is ambiguous since it could mean the present-day accumulation rate at the vertical of the ice particle.

b) It might be worth being precise that in all the integrations, zero is at the surface (since many integrations in glaciology actually treat the bed as zero).

Precision has been made.

c) Line 16: “relative density”: relative to what? If you use water equivalent accumulation rates, then your densities are relative to that of water, and I think that, for eq 4 and 2 to be right this has to be so. However in the files online it looks as if acc rates may be in metres ice equivalent, and in that case for eq 1 to be right the densities would be relative to ice. In any case this needs to be made clear and consistent.

Everything is relative to ice here : D is a relative density (1 minus the porosity), a is expressed in m ice-equivalent per year. We tried to make this clear in the revised manuscript.

d) And indeed you should be clear what your acc rates are. Many readers would assume they would have units kg mˆ-2 timeˆ-1. But actually they are in m (water or ice) equivalent depth timeˆ-1.

Clarified.

As a general comment, at different times in the text you use “I” (eg p 6817, line 25), “we/us” (6818, line 2), or “one” (6817, line 16). You should standardise.

"I"s have been replaced by "we"s. "one" has a different meaning.

Section 2.8. Probably it was intended but just to avoid doubt, the model code should be a supplement to the paper. I appreciate that the code is available at github. However (a) it looked like a rather confusing set of files; (b) it is not clear which set of files corresponds to the model version presented and tested in the paper; (c) the software archive should be permanent and secure, and with great respect I don’t think a personal area on even the most secure server meets that bill. I therefore suggest that the files referring to this version of the paper should be archived at GMD as a supplement.

Agree, the code will also be made available as a supplement.

Section 2.7 (comparison to Datice), also page 6826, line 25 claiming superiority of Ice Chrono. I am unable to judge these sections: one of the developers of DATICE should be strongly urged to comment.

We now give the precision that the comparison is based on the published version of Datice (Lemieux-Dudon et al., QSR, 2010). Also the comparison that we now provide between Datice and IceChrono has been discussed with the developers of DATICE.

Page 6824, line 14: can the author comment what is occurring in the DATICE code that causes it not to respect the confidence interval at the tie point? Knowing this would be very helpful in judging the way the models work.

We now use the raw confidence intervals as produced by Datice and not the AICC2012 confidence intervals. The raw Datice confidence interval does respect the observations confidence interval during the Laschamp event.

Page 6825, Berkner age model. By synchronising on water isotopes the author is assuming synchronous climate changes between Berkner and East Antarctica. This assumption (which precludes testing phase leads and lags) should be made absolutely explicit.

Following the suggestion made by the other reviewers, we have now removed the Berkner experiment in the revised version.

Also re Berkner expt: I wonder why the author has done this in such a way that the Berkner age scale has only the synchro error. It would surely have been straightforward to in addition simply run AICC2012 again but including Berkner, in order to get a realistic uncertainty on the Berkner age model. As there would have been no new absolute age information, I assume that the ages would not have altered for the other cores, but an uncertainty for Berkner would have emerged.

Dito.