We would like to thank anonymous referee #1 for the constructive and thoughtful comments and suggestions.

Below, we respond to the suggestions of Reviewer#1 (and have copied - where relevant – the remarks in green).

MAJOR COMMENTS

Reviewer#1: I think fundamentally there is some confusion over the information realistically preserved in cosmogenic depth profiles. In some cases, a measured depth profile can converge to a unique solution for both of age and erosion rate (as described by Braucher et al. 2009). I would argue that these cases are very rare as it requires characterizing both the spallogenic and muogenic production pathways with the dataset.

Reply: We fully agree that one should carefully consider which information can realistically be preserved in CRN depth profiles. In our opinion, Bayesian inference is especially powerful when it comes to determine how well the model parameters can be resolved by the available data. Using Bayesian techniques, we can explore the information content that is hidden in the data, and get an uncertainty on the model estimates. Our Bayesian inverse methodology is a statistically-sound tool for quantifying to what extent the model parameters are constrained by the available measurement data. The Bayesian approach considers the model parameters to be random variables having a joint posterior probability density function (pdf). Once determined, this posterior distribution encodes all the necessary information about the parameters such as degree of (non-) uniqueness, standard deviations, correlations and dependencies (given the chosen prior distribution and likelihood function). We will better highlight the advantages of Bayesian inference in the revision.

Reviewer#1: Without such characterization and without other independent geologic constraint, a profile will not yield a unique solution for age and erosion rate, but it can still yield a minimum exposure age (or zero erosion age), and a maximum erosion rate for $t \rightarrow \infty$.

Reply: To come back to our presented results, we thus consider that they rigorously represent the information content of the investigated profile. The reviewer points out that a single depth profile usually cannot simultaneously resolve t (exposure age) and E (erosion rate). We would like to stress that this is exactly what our results are showing. With a marginal posterior distribution identical to its marginal prior distribution, the exposure age is not at all resolved (see Figures 7a and 8a). In contrast, we demonstrate that the erosion rate can be resolved, yet with a relatively large uncertainty that we quantify rigorously (see Figures 7b and 8abc, and lines 265-267).

Reviewer#1: When the authors interpret the Campine data, they impose an age constraint of 0.5-1 Ma, which essentially restricts their solution space to the erosion asymptote and removes any variance in erosion that would be present if younger ages were permitted. It should be noted that this is perfectly OK to do if the age constraints are robust. However, depth profiles are not necessarily applicable to the timespan since deposition, and unfortunately that seems to be the case for the Campine data…. The authors constrain the age of their profile to between 0.5-1 Ma based on preexisting age constraints for deposition age. However, the landform that developed following deposition could be, and likely is, significantly younger. Any age constraint applied to a depth profile must consider the time over which the surface can be assumed to be in steady-state erosion. … If the age constraint that led to resolving the erosion rate is not viable, then the erosion rate is also not viable. The probability distribution of the erosion rate parameter needs to be re-calculated without a constraint on a lower age limit.

Reply: We fully agree with reviewer #1, and will re-run our Bayesian inversion using a wider prior distribution for the exposure age, and without putting a constraint on the lower age limit. The text, tables and figures will be revised accordingly, as this might modify the outcome of the Bayesian model.

The constraint for exposure age of 0.5 to 1 Myrs that was used in the manuscript, came from our initial assumption that the depth profile is only marginally affected by post-depositional erosion. While this assumption might now seem at odds with the current results, there is a general consensus which explains the Campine Plateau as a classical case of relief inversion, with coarse-grained fluvial deposits (gravel, sandy gravel and gravelly sand) on top protecting it from significant erosion (Paulissen, 1983; Paulissen, 1997). Our depth profile is sampled at the crest of the Campine Plateau, i.e. at the top of the geomorphic surface. Our CRN results question the consensus on the stability of the Campine Plateau: when assuming near-zero denudation rates, the apparent exposure age should be congruent with the minimum depositional age of the Rhine sands in this location that is estimated to be ca. 0.5 Ma (absolute lower age estimate, see text). The Quaternary geology of Rhine and Meuse deposits, the entire history of the Meuse terrace staircase and the evolution of the Roer Valley Graben all point to a late Early to early Middle Pleistocene age for the fluvial deposits (see text for references).

We agree that we should extent the prior distribution for t down to t=0, to capture the possibility of post-depositional erosion at the site.

MINOR COMMENTS

We will try to address the additional minor comments of the reviewer as follows:

Reviewer#1: Bayesian/Monte Carlo-style models have previously been applied to cosmogenic depth profiles (see version 1.2 of Hidy et al. (2010) described in Mercader et al. (2012) supplemental code; see Marrero et al. (2016), CRONUS web-based calculator).

Reply: We will better acknowledge previous literature on Monte-Carlo simulation and uncertainty estimation for CRN applications. That stated, to the best of our knowledge our work is the first to apply Bayesian uncertainty quantification to CRN modeling. Indeed, the plain Monte Carlo procedure used by Hidy et al. (2010) is not Bayesian. Hidy and coworkers do not consider Bayes theorem and from a statistical point of view, their uncertainty estimates have a different meaning than ours. We believe that our Bayesian approach is both more sound and more robust. This will be clarified in the revision.

Reviewer#1: Thicknesses do not appear to be given for the profile samples

Reply : The sample thickness is 10 cm and we will properly address this issue in the revised text.

Reviewer#1: Our knowledge of production rate scaling has increased significantly over the past 5 years. The authors may want to use something more up-to-date based on all the recent calibration data

Reply: As written in lines 129-131 of our submitted manuscript, we used the same CRN production rates as the ones used by Rixhon et al. (2011). This choice was made for the sake of comparison –as in the study by Rixhon and coworkers a Middle Pleistocene Meuse terrace around Liège was investigated. However, we tend to agree now with the fact that we should use state-of-the-art knowledge on scaling and production rates of CRN's. We will use the updated data suggested by the reviewer when re-running the Bayesian model.

REFERENCES

Hidy, A. J., Gosse J. C., Pederson J. L., Mattern J. P., and Finkel R. C., 2010. A geologically constrained Monte Carlo approach to modeling exposure ages from profiles of cosmogenic nuclides: An example from Lees Ferry, Arizona, Geochem. Geophys. Geosyst., 11, Q0AA10, doi:10.1029/2010GC003084.

Paulissen, E., 1983. Les nappes alluviales et les failles Quaternaires du Plateau de Campine. In: Robaszynski F, Dupuis C (eds) Guides Géologiques Régionaux – Belgique, Masson, Paris, pp. 167-170.

Paulissen, E., 1997. Quaternary morphotectonics in the Belgian part of the Roer Graben. Aardkundige Mededelingen 8, 131-134.

Rixhon, G., Braucher, R., Bourlès, D., Siame, L., Bovy, B., Demoulin, A., 2011. Quaternary river incision in NE Ardennes (Belgium)-Insights from 10Be/26Al dating of river terraces, Quaternary Geochronology, 6 (2), 273-284.