Dating of a German lake sediment with high human impact

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Introduction

Chronology using $^{210}Pb_{xs}$
Sediment Chronology using classical models is based on determining the unsupported $^{210}Pb_{xs}$ which reaches the lake surface. The unsupported $^{210}Pb_{xs}$ can be determined by subtracting from the total activity signal the supported activity which is continuously produced within the sediment and assuming secular equilibrium between ^{226}Ra and the daughter products.

Goals
In this work we attempted to use both classical models in a lake environment where models assumptions (CF-CS: constant flux and constant sedimentation) and (CRS: constant rate of $^{210}Pb_{xs}$ supply) might not be fulfilled (Abril 2004, Sanchez-Cabeza and Ruiz-Fernández 2012).
In this aspect, extra information about the time events happened in the vicinity of the sampling area will be used as “markers” (Tab. 1).

Date	Eutrophication sources	Oligotrophication measures
until 1970	loading of the lake with communal and industrial sewage of the town of Arendsee	
1960–1970	drainage of Lake Fauler See into Lake Arendsee (input of loaded water, enlargement of the catchment area, input of drain water of the agriculturally used area of the ancient Lake Fauler See)	
since 1960	intensification of agriculture in the catchment area intensification of the fishery (high stocking of whitefish)	
1960–1970		construction of a canal for the town of Arendsee
1976		installation of a hypolimnetic withdrawal
1995		flushing of marl

Tab 1. *Events in the lake Arendsee during the las 50 years.*(Scharf, 1998)

Fig. 2.Location of the sediment core. Source: openstreetmap.org

Methods

Sampling
The sampling point is located in the deeper part of the lake Arendsee, situated in northern Germany (52° 53′21″ N, 11° 28′27″ E). It has a maximal depth of 48 m and an average depth of 29 m. The hydraulic residence time of the water is 50-60yr on average (Fig. 2).
The Arendsee is a dimictic, eutrophic karst lake in the actuality. Until 1896 it was oligotrophic, in 1960 mesotrophic and finally in 1972 changed to eutropic lake.
The core was extracted on October 2014. After the extraction it was sliced into 1cm layers, freeze-dried, homogenized by grinding, pressed into pellets and sealed using radon-tight aluminum barrier foil. After sealing, samples were stored during at least 3 weeks awaiting the secular equilibrium between ^{226}Ra and ^{222}Rn.

Detection
A HPGe detector with carbon window housed in a 10 cm Pb shielding with Cu, Cd and plastic inner linings and operated by Genie 2000 software was used. Efficiencies had been generated using LabSOCS software.

Results

Measurements
Results from the gamma-spectrometric determinations are presented in Fig. 3.
The fit function was calculated using the upper and lower part of the $^{210}Pb_{xs}$ and avoid the region of high impact. Afterward historical points were compared with chronology implemented using $^{210}Pb_{xs}$ (Fig.4) .
Results indicate a partial agreement between the sedimentation rates derived by both models (Fig.4) in time-spaces where no human impact was done. Chronologies with both models show comparables values in the upper part but with progressive disagree in the temporal region between 1970 and 1995 (19-44yr). After than between 44-57,5yr parallel chronology can observed again. The lower part of the core presents different chronologies with a high uncertainty.
Values of the Sedimentation rates R_s show acceptable values in almost all profile of the core with exception in the depth 12-15cm where the Ca-rich layer was found.

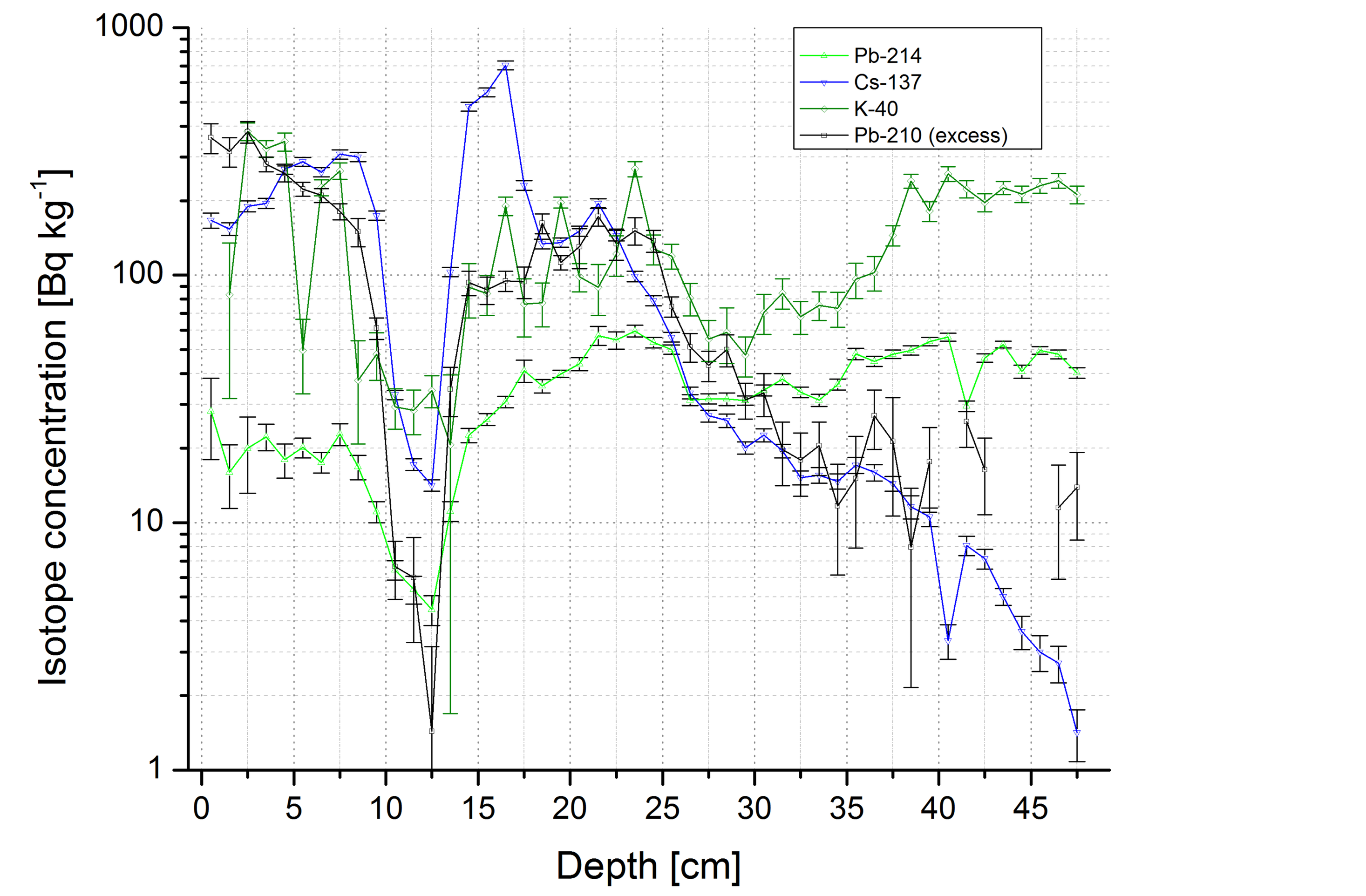

Fig. 3. Depth distribution of the excess ^{210}Pb for lake Arendsee together with activity concentration of ^{40}K, ^{214}Pb and ^{137}Cs.

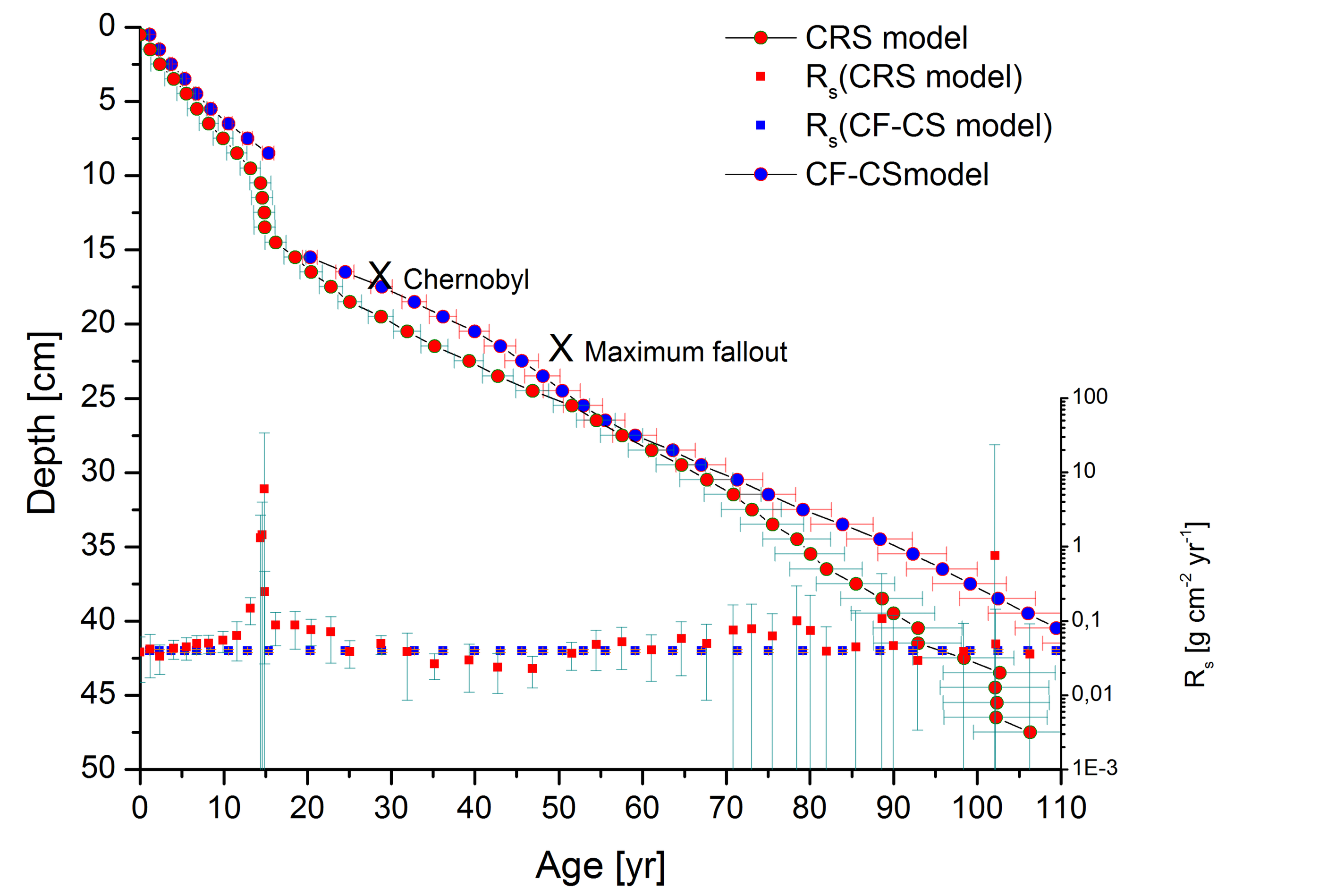

Fig. 4. Chronology of sediments from lake Arendsee. Comparison of the depth vs. age using models CF-CS (blue points) and CRS (red points). Sedimentation rates R_s are plotted for both models.

Conclusions and outlook

It could be shown that both models can be used for calculation of the sedimentation rate and to produce a sedimentation chronology. The results also show how a lake with high impact can be dated based on the use of historical time points like “markers” and expected areas where the $^{210}Pb_{xs}$ show exponential decrease.
The chronology developed in this work in cooperation with has been implemented (Rothe 2015) and supported by Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB).

References

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