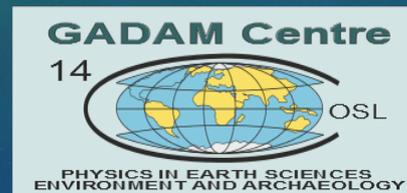


EVALUATING THE AGE-DEPTH MODELS BASED ON COUPLED ^{14}C AND ^{210}Pb DATA



**Silesian University
of Technology**



NATALIA PIOTROWSKA, JAROSŁAW SIKORSKI

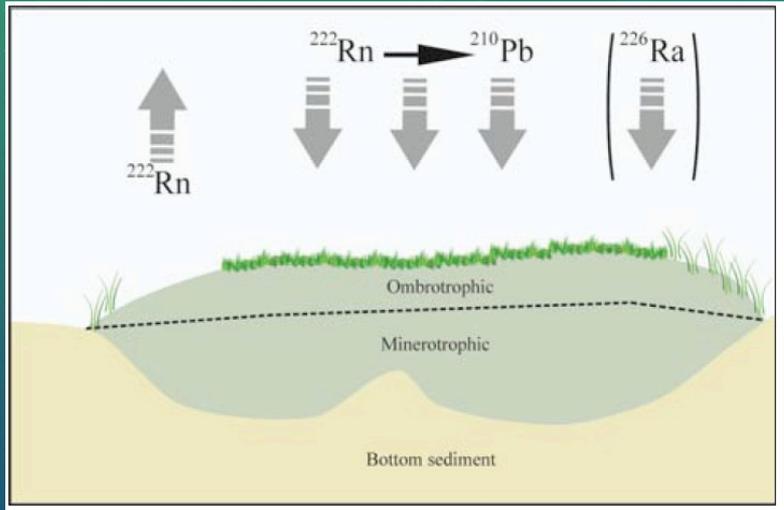
SILESIAN UNIVERSITY OF TECHNOLOGY, INSTITUTE OF PHYSICS-CSE
DIVISION OF GEOCHRONOLOGY AND ENVIRONMENTAL ISOTOPES
GLIWICE, POLAND

Natalia.Piotrowska@polsl.pl

- Introduction
- Results – ^{210}Pb calculations:
 - Classical old CRS
 - extrapolation procedure („new CRS”)
 - ModAge CRS calculations
- Results presentation – no age-depth modeling
- Comparison of age-depth modelling tools (GAM, clam, Bacon, OxCal) and their uncertainties
- Our preferred age-depth model ;-)
- Conclusions

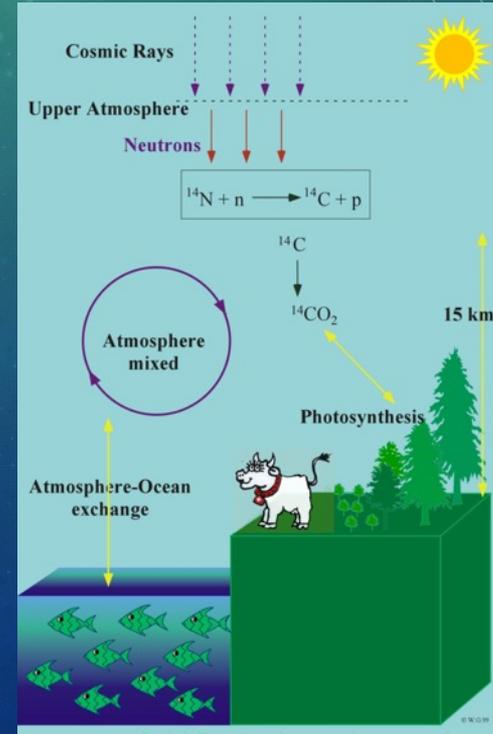
^{210}Pb and ^{14}C sources in an ombrotrophic peatbog

^{210}Pb $T_{1/2} = 22.6$ years
Source: U-decay chain
aerosol particles



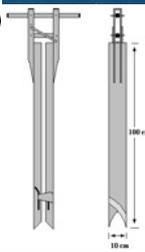
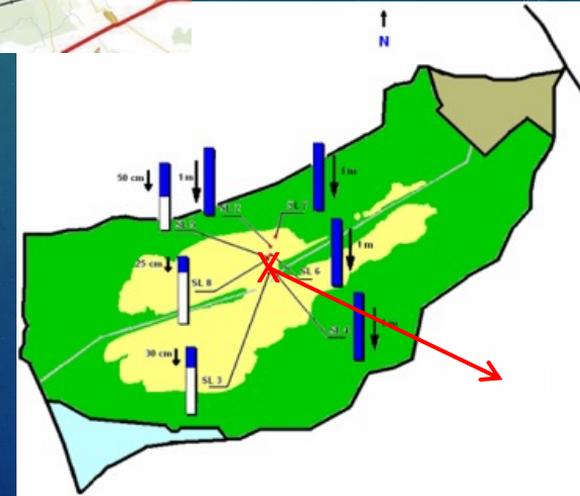
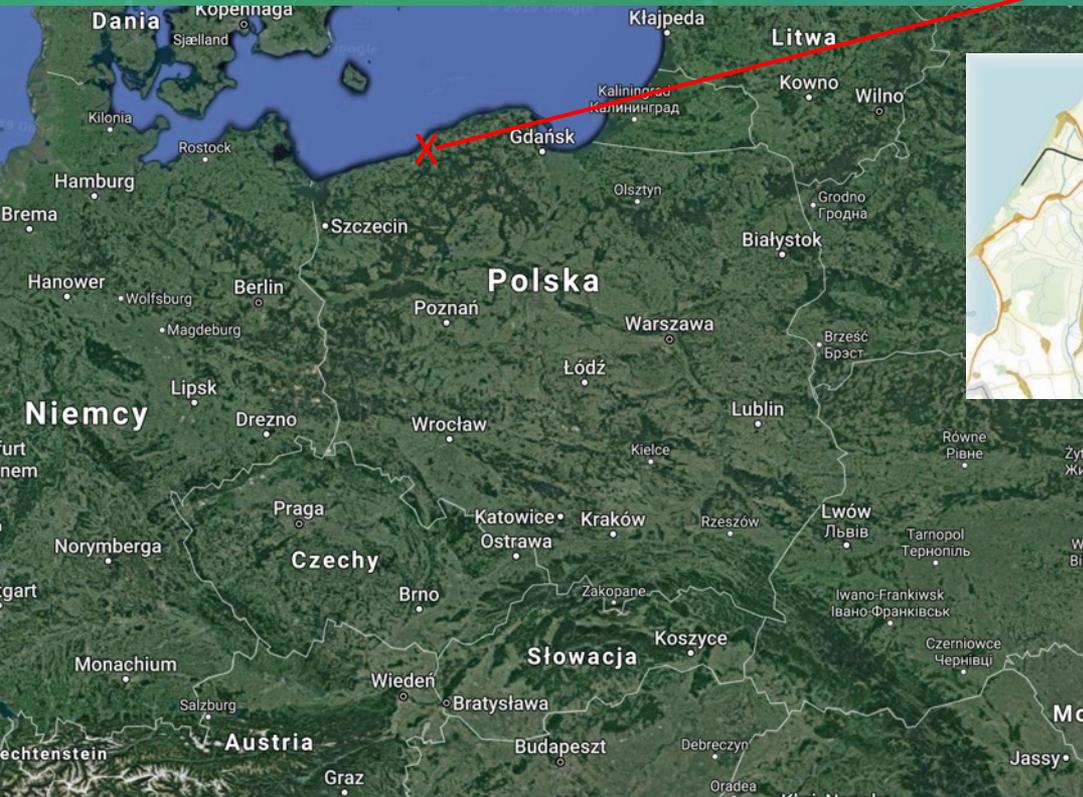
^{210}Pb sources in a peat-bog (De Vleeschouwer et al. 2010)

^{14}C $T_{1/2} = 5730$ years
Source: cosmogenic
 CO_2 - photosynthesis



Site and coring (AD 2006)

Słowińskie Błoto



blue - meadow; green - pine crop and birch (height to 12 m)
yellow - open peat bog; grey - draining ditches

^{210}Pb and ^{14}C measurements

^{210}Pb

- ✓ 1-cm thick samples
- ✓ sequential $\text{HNO}_3\text{-H}_2\text{O}_2\text{-HCl}$ digestion
- ✓ Po deposition on silver discs
- ✓ α activity measured
- ✓ supported ^{210}Pb activity (ca. 10 Bq/kg) below depth 34 cm



^{14}C

- ✓ 1-cm thick samples
- ✓ macrofossils selected
- ✓ acid-alkali-acid treatment
- ✓ graphite production
- ✓ AMS measurements of ^{14}C content
- ✓ calculation of ^{14}C ages



Site – publications

The Holocene 19,4 (2009) pp. 625–637

Multiproxy evidence of ‘Little Ice Age’ palaeoenvironmental changes in a peat bog from northern Poland

François De Vleeschouwer,^{1,2*} Natalia Piotrowska,² Jarosław Sikorski,² Jacek Pawlyta,² Andriy Cheburkin,³ Gaël Le Roux,¹ Mariusz Lamentowicz,⁴ Nathalie Fagel¹ and Dmitri Mauquoy⁵

 **BOREAS** An international journal of Quaternary research

Climate and human induced hydrological change since AD 800 in an ombrotrophic mire in Pomerania (N Poland) tracked by testate amoebae, macro-fossils, pollen and tree rings of pine

MARIUSZ LAMENTOWICZ, KRYSZYNA MILECKA, MARIUSZ GALKA, ANNA CEDRO, JACEK PAWLYTA, NATALIA PIOTROWSKA, LUKASZ LAMENTOWICZ AND WILLEM O. VAN DER KNAAP

Contents lists available at [ScienceDirect](#)

Science of the Total Environment

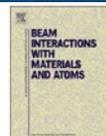
journal homepage: www.elsevier.com/locate/scitotenv



Contents lists available at [ScienceDirect](#)

Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb



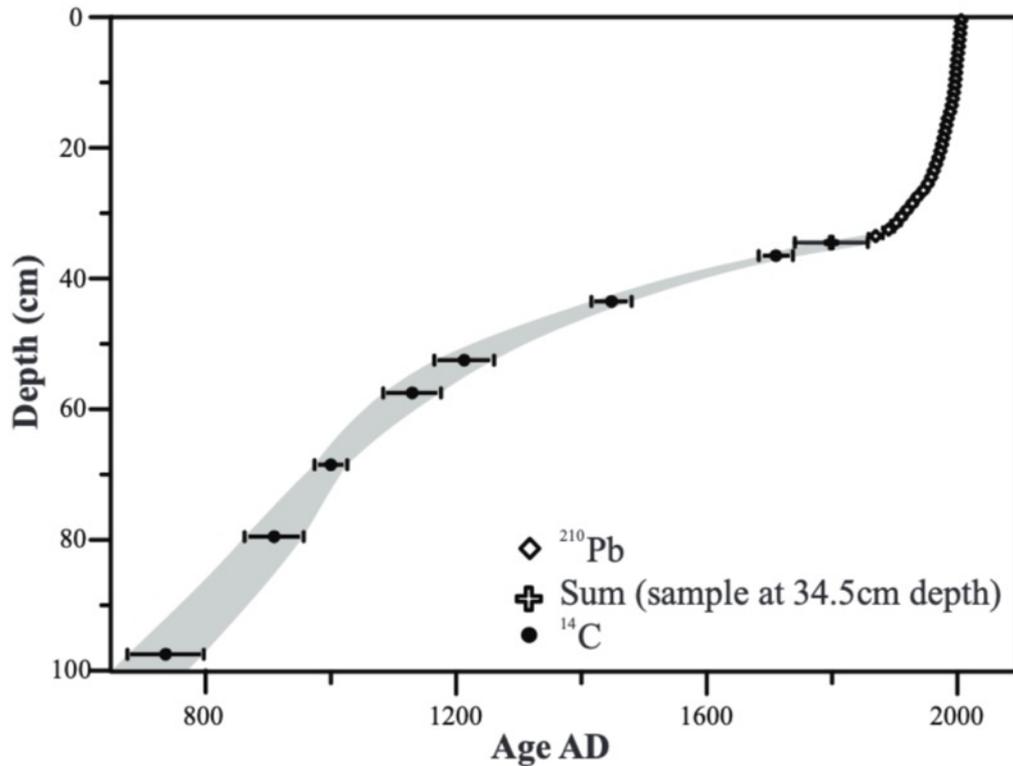
Anthropogenic impacts in North Poland over the last 1300 years – A record of Pb, Zn, Cu, Ni and S in an ombrotrophic peat bog

François De Vleeschouwer^{a,c,*}, Nathalie Fagel^c, Andriy Cheburkin^b, Anna Pazdur^a, Jarosław Sikorski^a, Nadine Mattielli^d, Virginie Renson^e, Barbara Fialkiewicz^f, Natalia Piotrowska^a, Gaël Le Roux^{c,1}

Intercomparison of radiocarbon bomb pulse and ²¹⁰Pb age models. A study in a peat bog core from North Poland

Natalia Piotrowska^{a,*}, François De Vleeschouwer^{a,1}, Jarosław Sikorski^a, Jacek Pawlyta^a, Nathalie Fagel^b, Gaël Le Roux^{b,2}, Anna Pazdur^a

Age-depth model – status for AD 2008, published



De Vleeschouwer et al. 2009
(*The Holocene*)

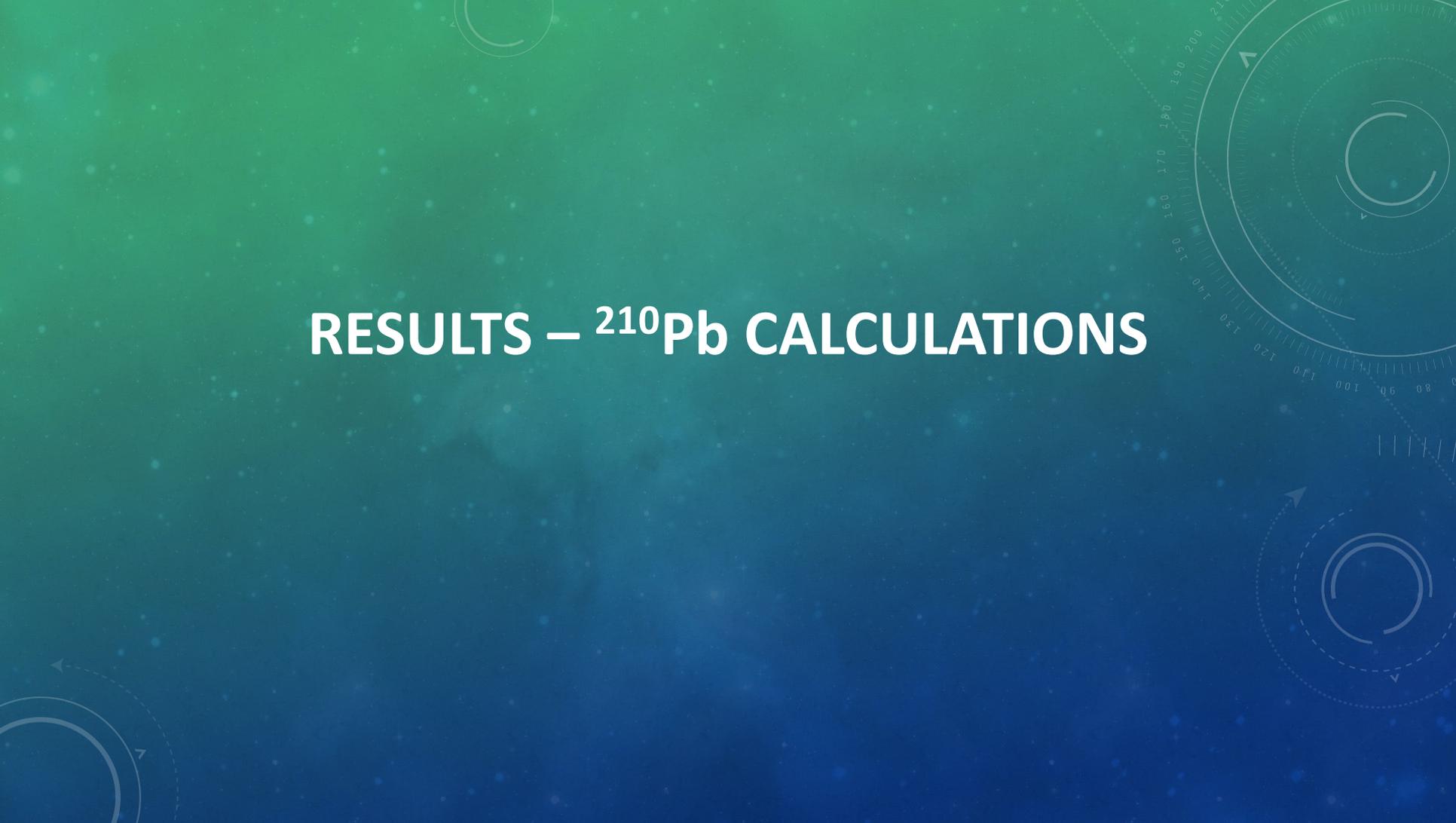
- ^{210}Pb and 8 ^{14}C dates
- OxCal *P_Sequence* calibration
- GAM (*generalized additive model*) age-depth modelling (Heegaard et al. 2005)

UPDATES:

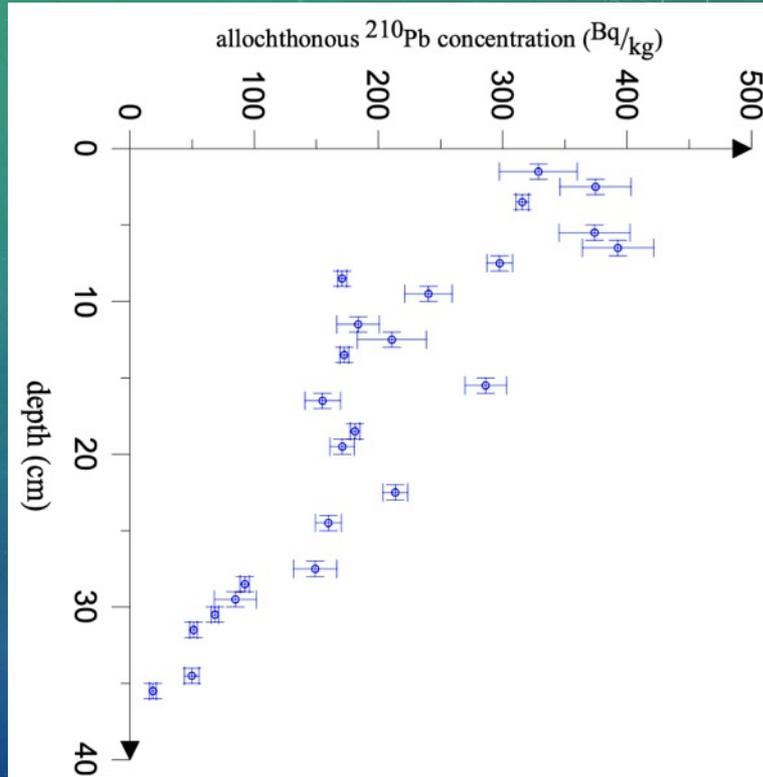
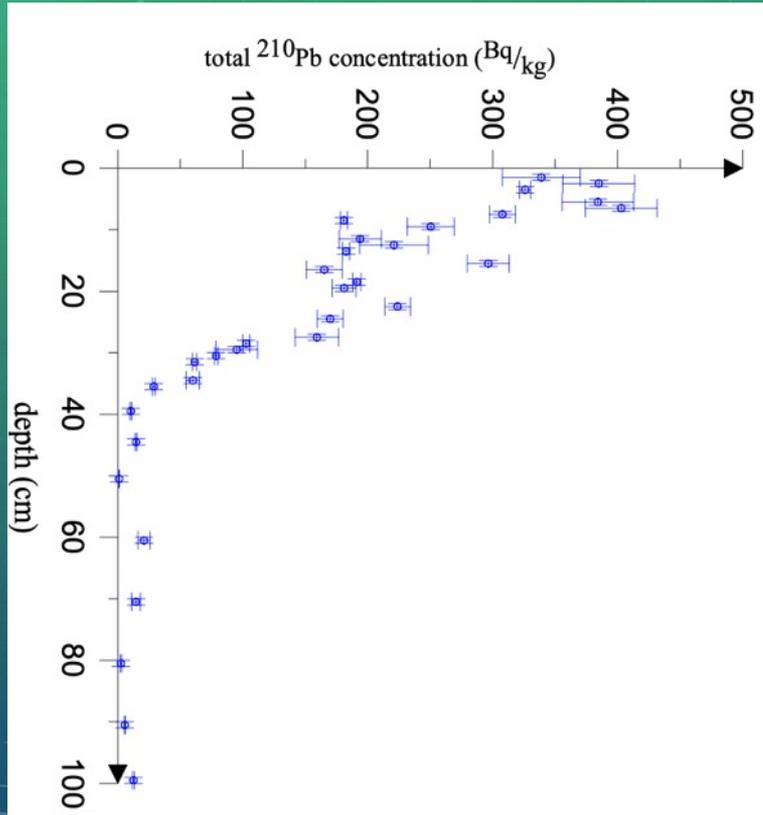
- ✓ More ^{14}C dates
- ✓ ^{210}Pb methodology
- ✓ Calibration curves
- ✓ Age-depth modeling tools



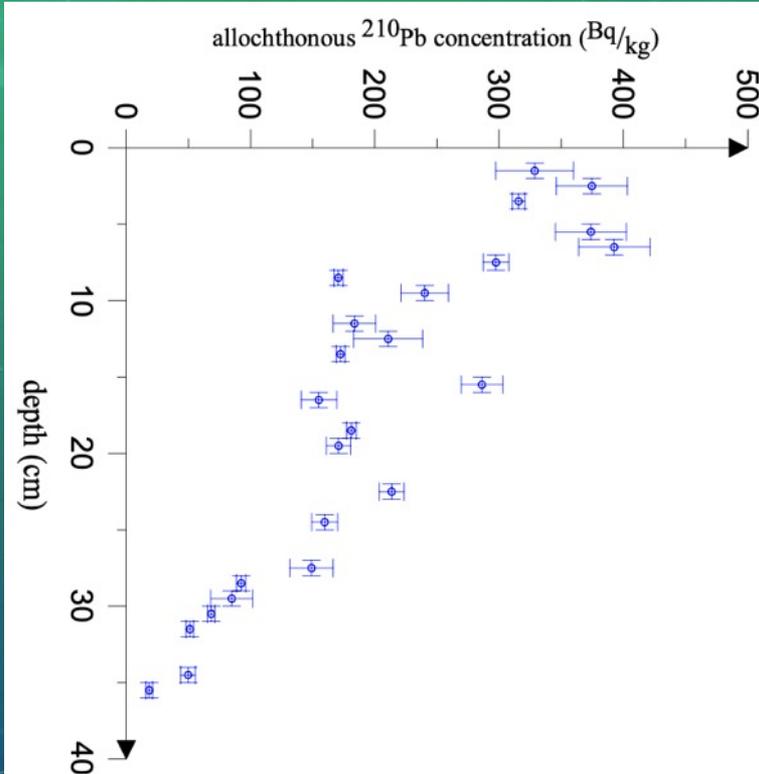
RESULTS – ^{210}Pb CALCULATIONS

The background features a vertical gradient from green at the top to blue at the bottom. On the right side, there are several technical diagrams, including a large circular scale with numerical markings from 80 to 200 and a smaller circular diagram below it. On the left side, there are faint circular diagrams, one of which is partially visible at the bottom left.

Raw results - ^{210}Pb activity

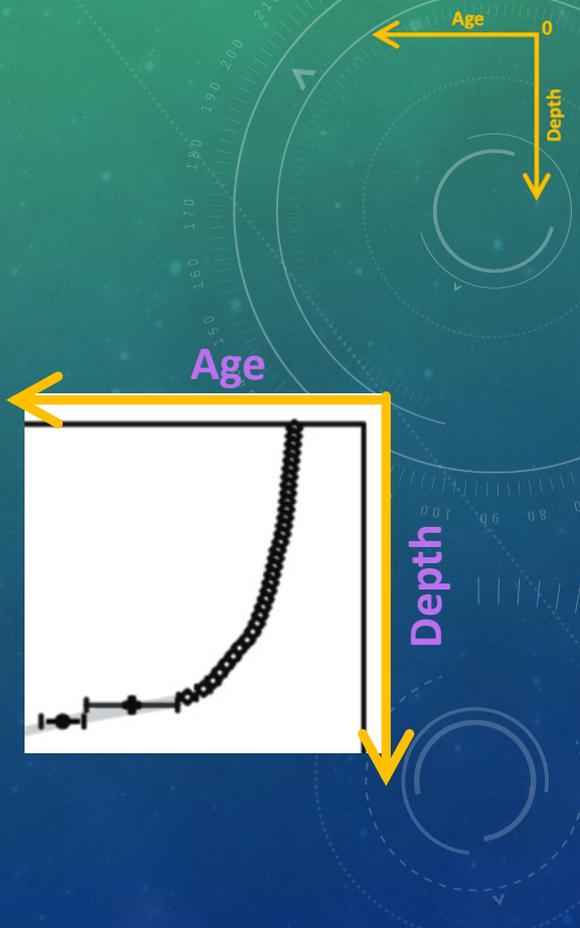


Raw results - ^{210}Pb activity



CRS model
(Constant Rate
of Supply)
+ water content

==



Extrapolation of the unsupported ^{210}Pb activity

sciendo

GEOCHRONOMETRIA 46 (2019): 1–14
DOI 10.1515/geochr-2015-0101

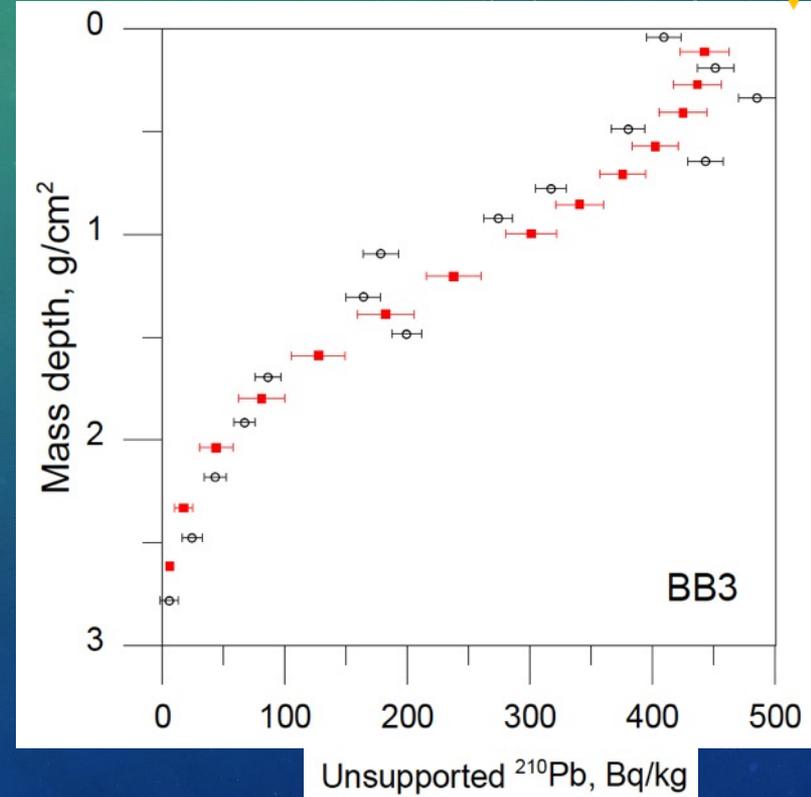
Available online at
<https://content.sciendo.com/view/journals/geochr/geochr-overview.xml>



A NEW METHOD FOR CONSTRUCTING Pb-210 CHRONOLOGY OF YOUNG PEAT PROFILES SAMPLED WITH LOW FREQUENCY

JAROSŁAW SIKORSKI

Silesian University of Technology, Institute of Physics – Centre for Science and Education, Konarskiego 22B, 44-100 Gliwice, Poland



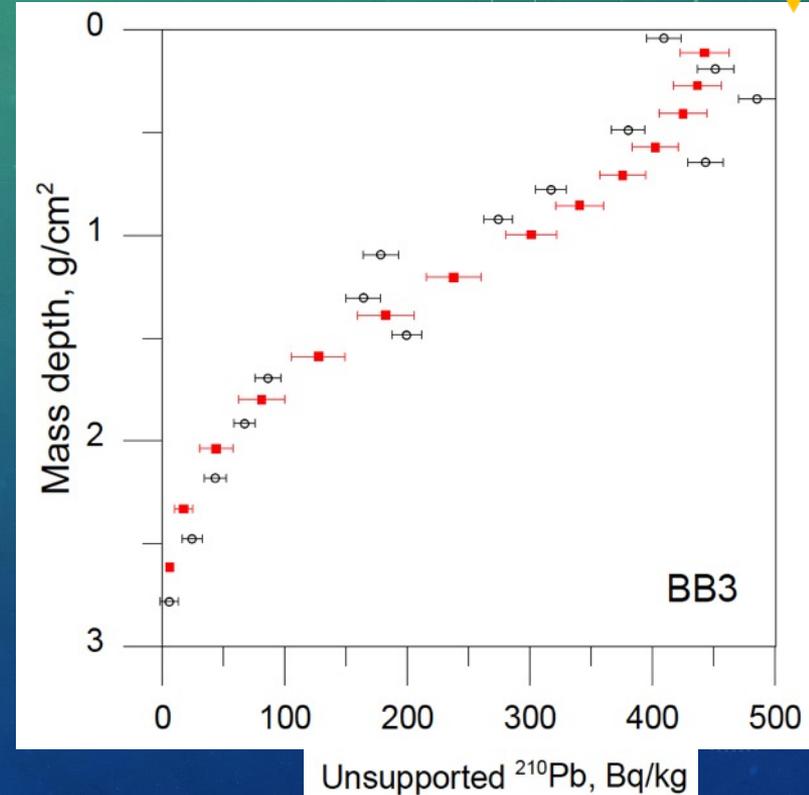
Extrapolation of the unsupported ^{210}Pb activity

- use mathematical function which best fits the measured activity
- use F -statistics as the measure of the match quality
- the best extrapolation results (*TableCurve* software, 3665 possibilities) were obtained for the functions described by the same formula for all cores:

$$\ln y = a + bx^c$$

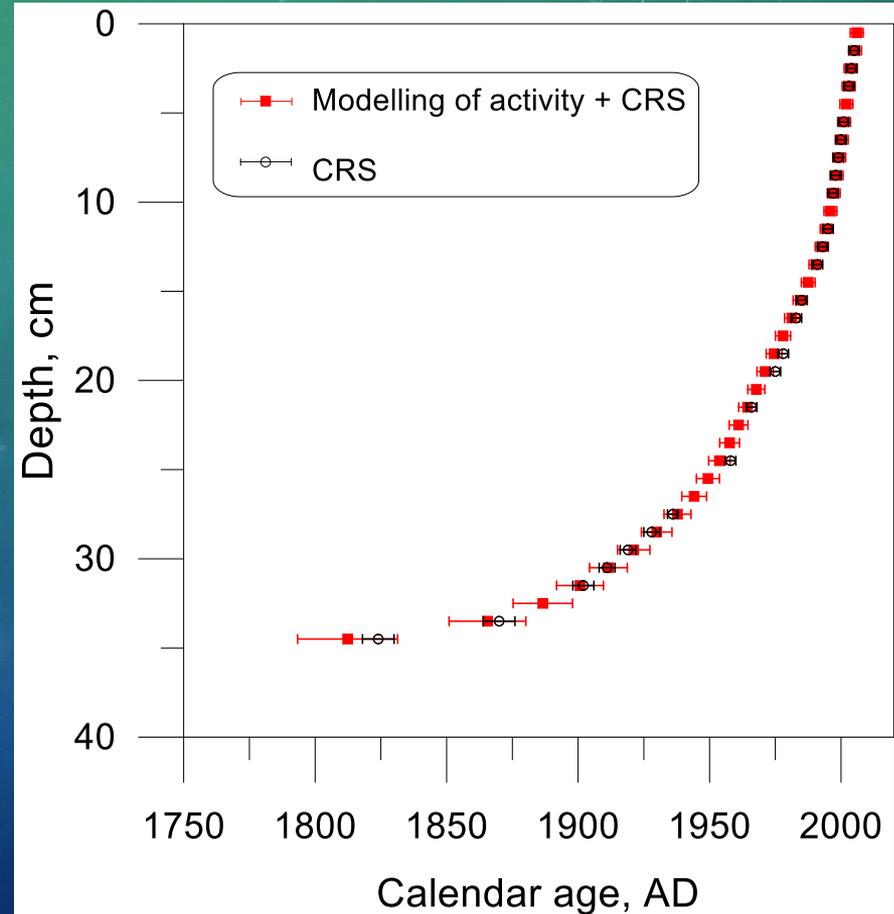
where:

- x – depth mass (g/cm^2)
- y – specific activity of unsupported ^{210}Pb (Bq/kg)
- a, b, c – the parameters of the matched function

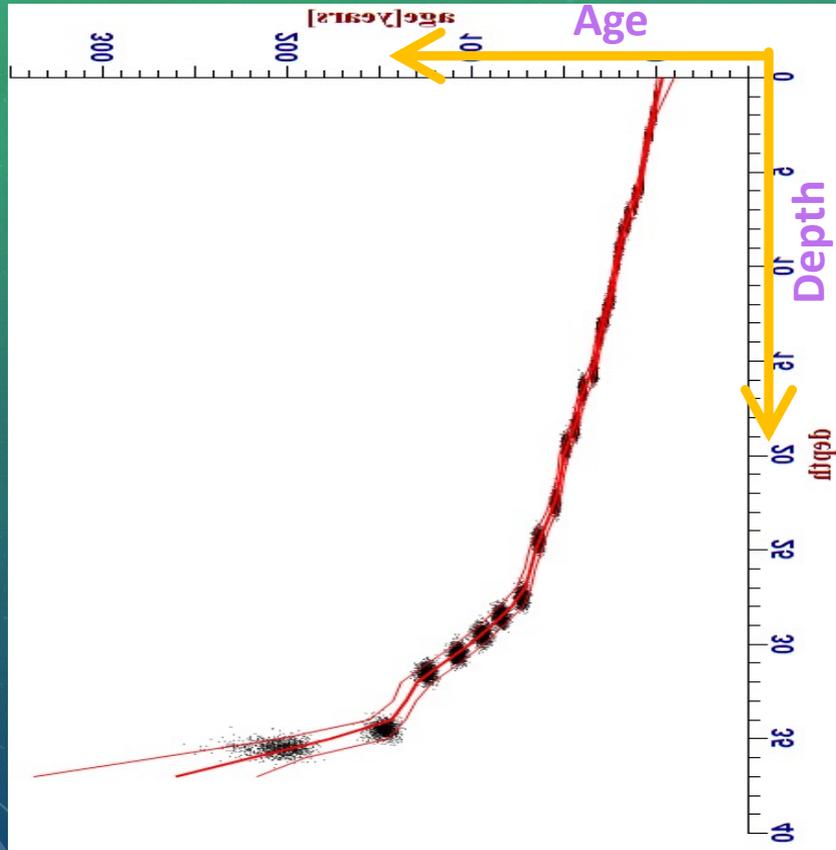


^{210}Pb derived ages – CRS models

- For SL4 the parameters are:
 - ✓ $a = 5.76$
 - ✓ $b = -5.15 \cdot 10^{-5}$
 - ✓ $c = 3.00$
- and the formula is:
 - $\ln y = 5.76 - 5.15 \cdot 10^{-5} x^3$
- The value of F -statistic for the SL4 peat core:
 - ✓ $F = 169$



^{210}Pb derived ages – Mod-Age



“The MOD-AGE model takes into consideration not only the uncertainty of activity measurements but also the uncertainty of depth determinations and complete information about the distributions of both values.”

Hercman and Pawlak, 2012

Hercman et al., 2014

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Quaternary Geochronology

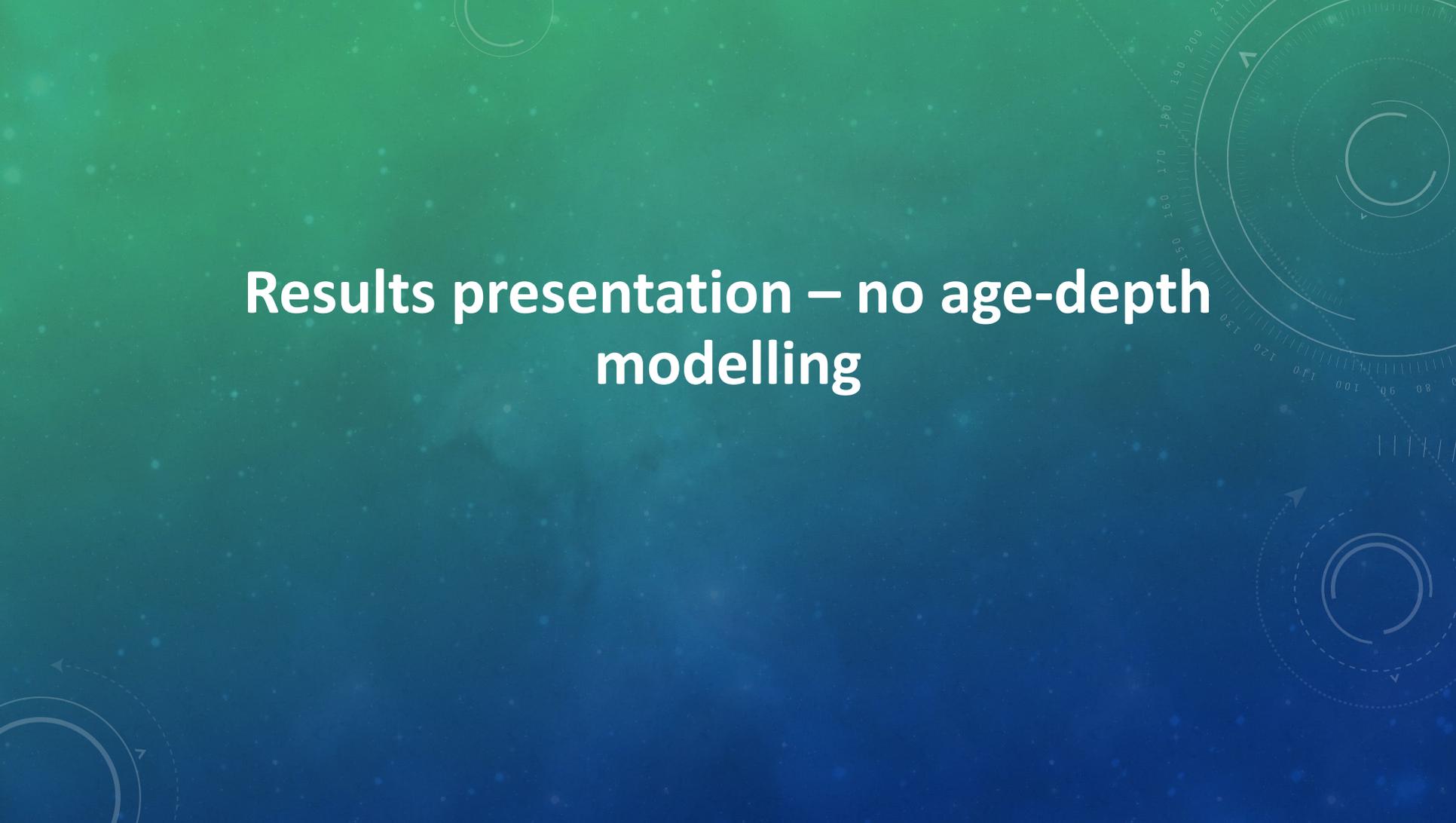
ELSEVIER journal homepage: www.elsevier.com/locate/quageo

QUATERNARY GEOPHYSICS

Research paper

MOD-AGE: An age-depth model construction algorithm

H. Hercman, J. Pawlak*



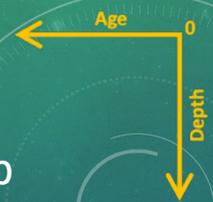
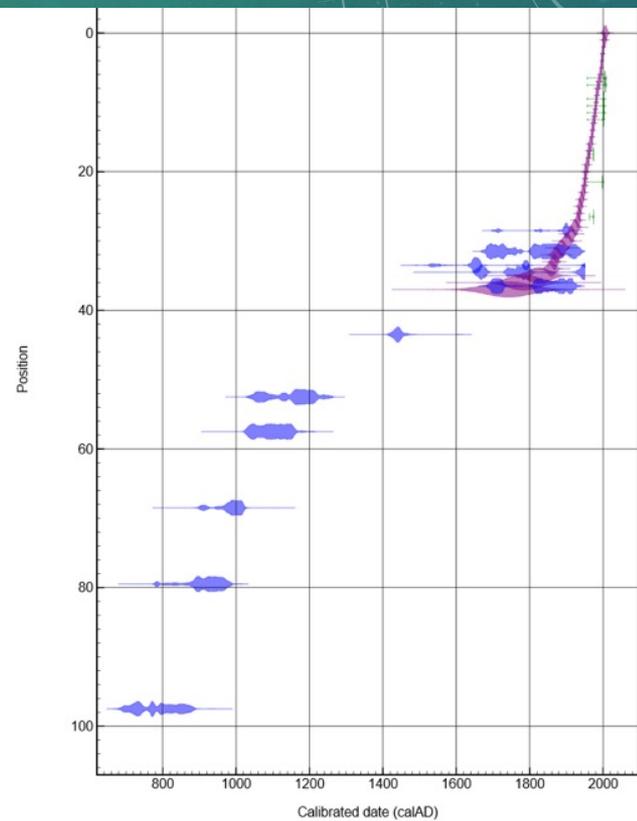
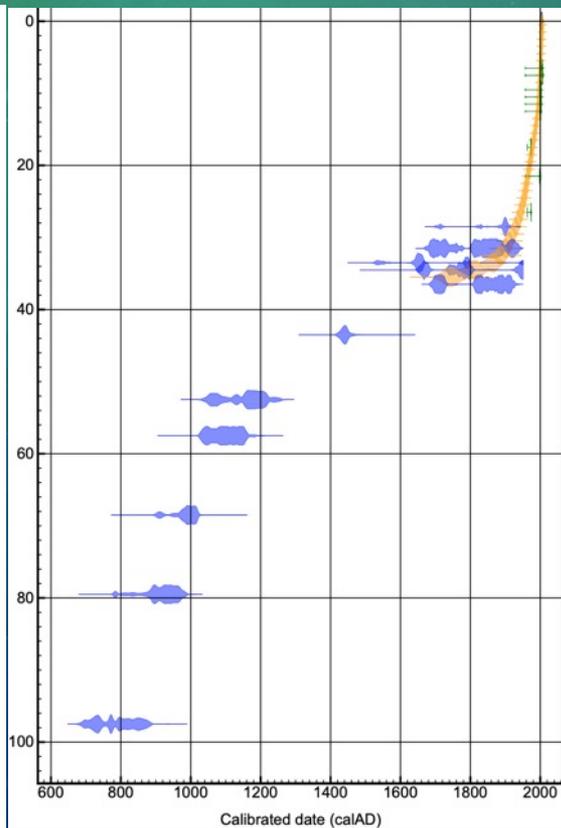
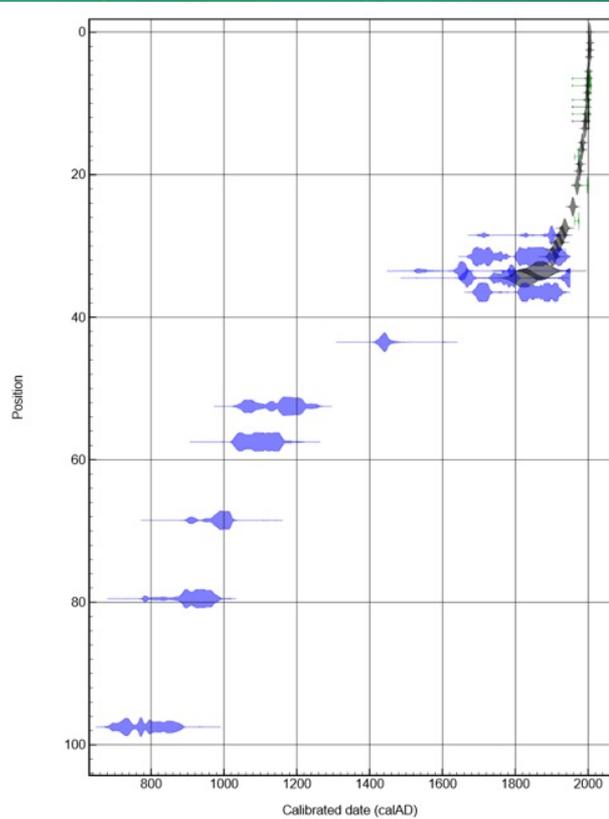
**Results presentation – no age-depth
modelling**

^{210}Pb and ^{14}C ages

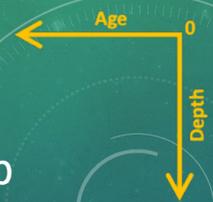
Old ^{210}Pb CRS

New ^{210}Pb CRS

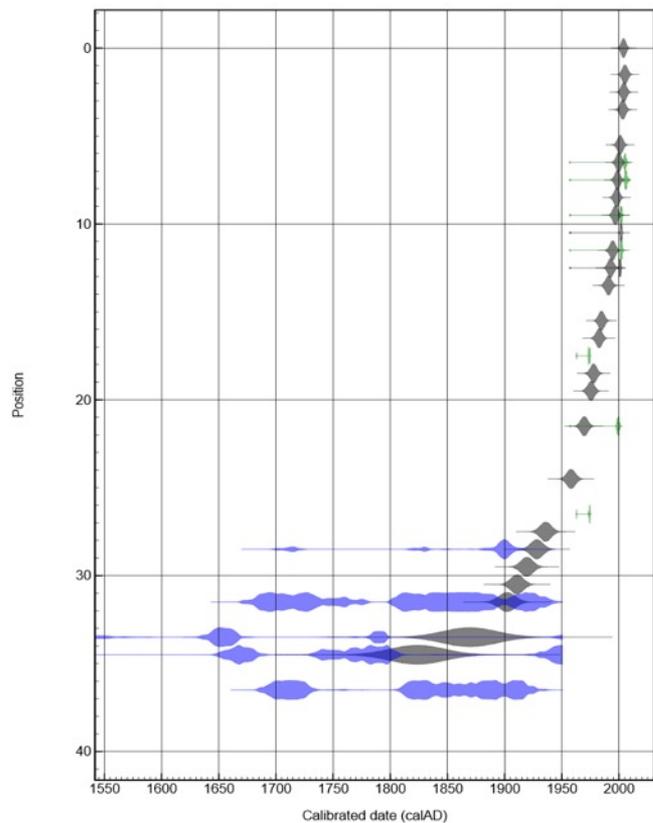
ModAge ^{210}Pb



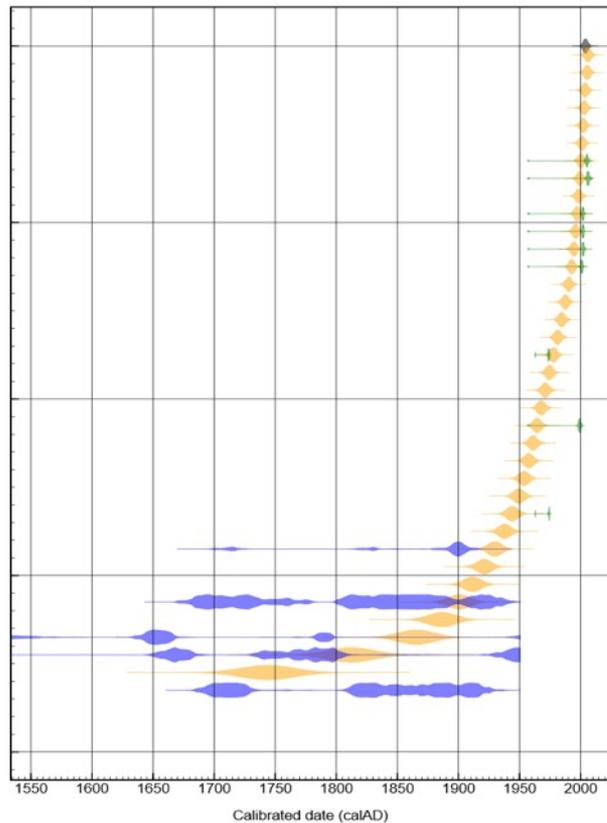
^{210}Pb and ^{14}C ages



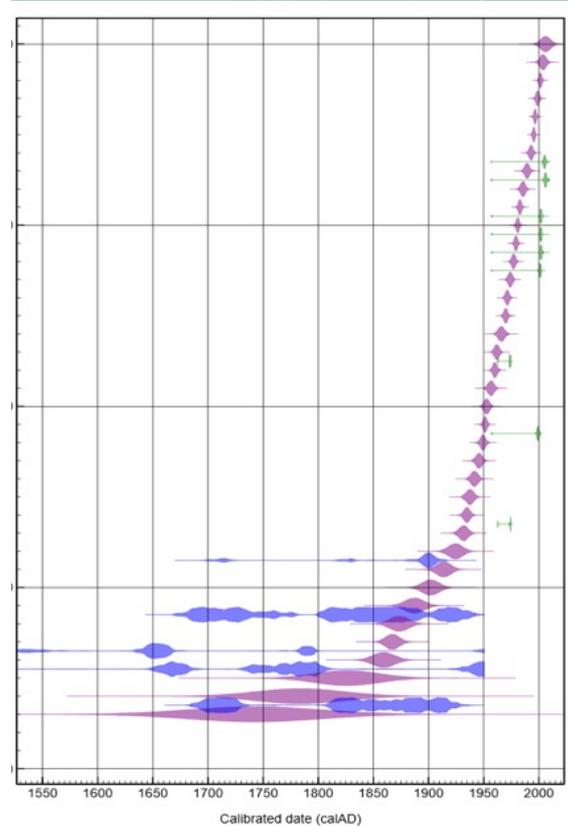
Old ^{210}Pb CRS



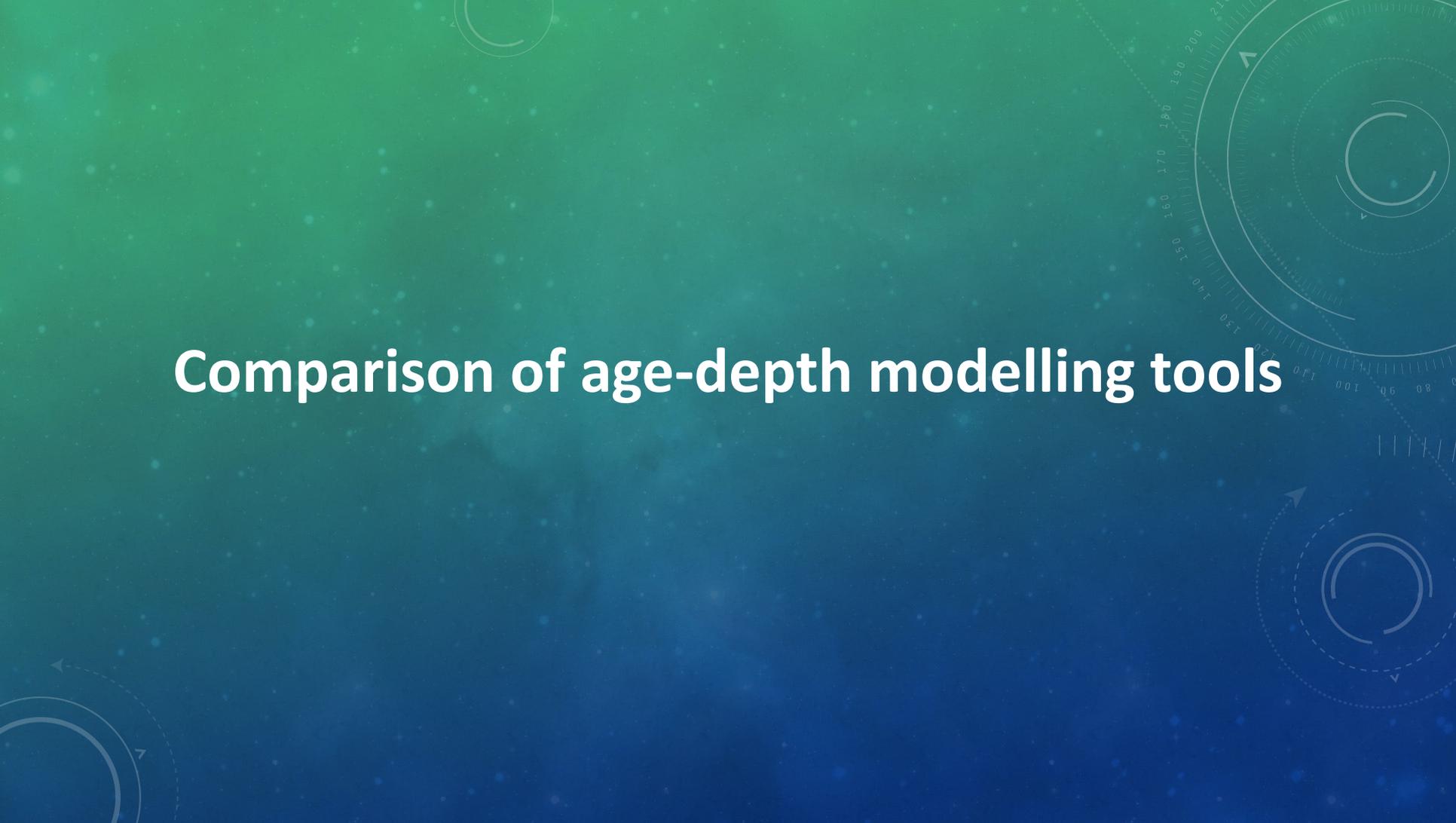
New ^{210}Pb CRS



ModAge ^{210}Pb



Comparison of age-depth modelling tools

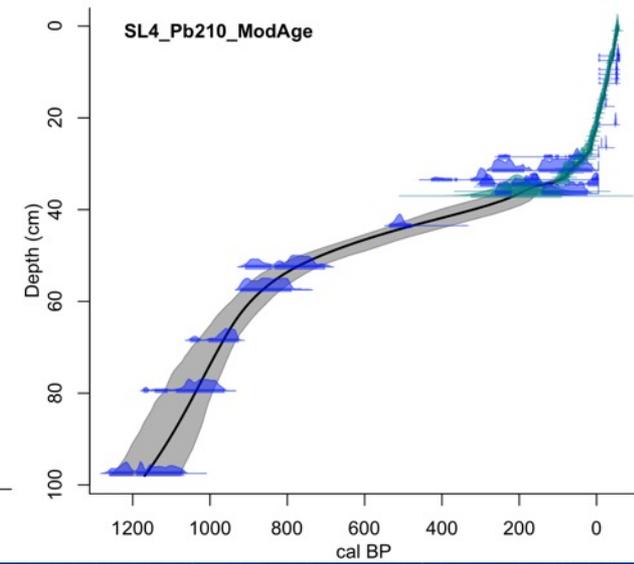
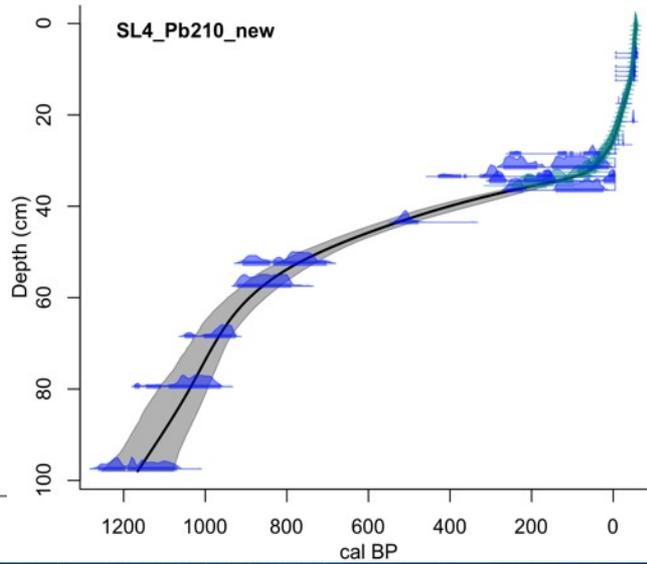
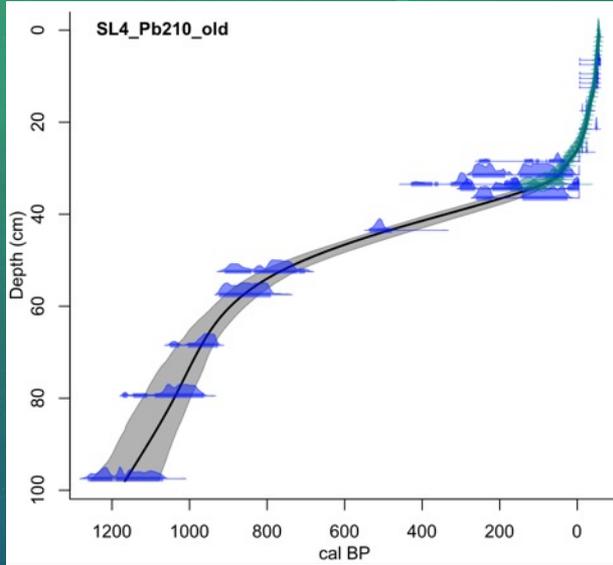
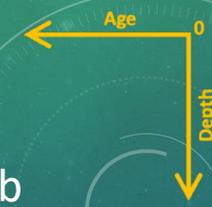
The background features a gradient from green at the top to blue at the bottom, overlaid with a field of small white stars. Several faint, semi-transparent circular gauges or dials are scattered across the image, some with numerical markings and arrows, suggesting a technical or scientific theme.

Clam models (smooth spline)

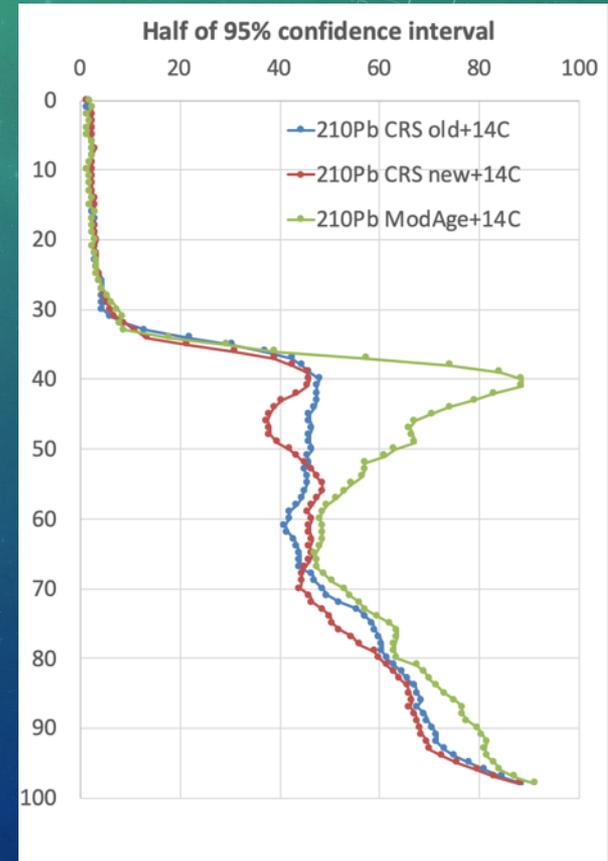
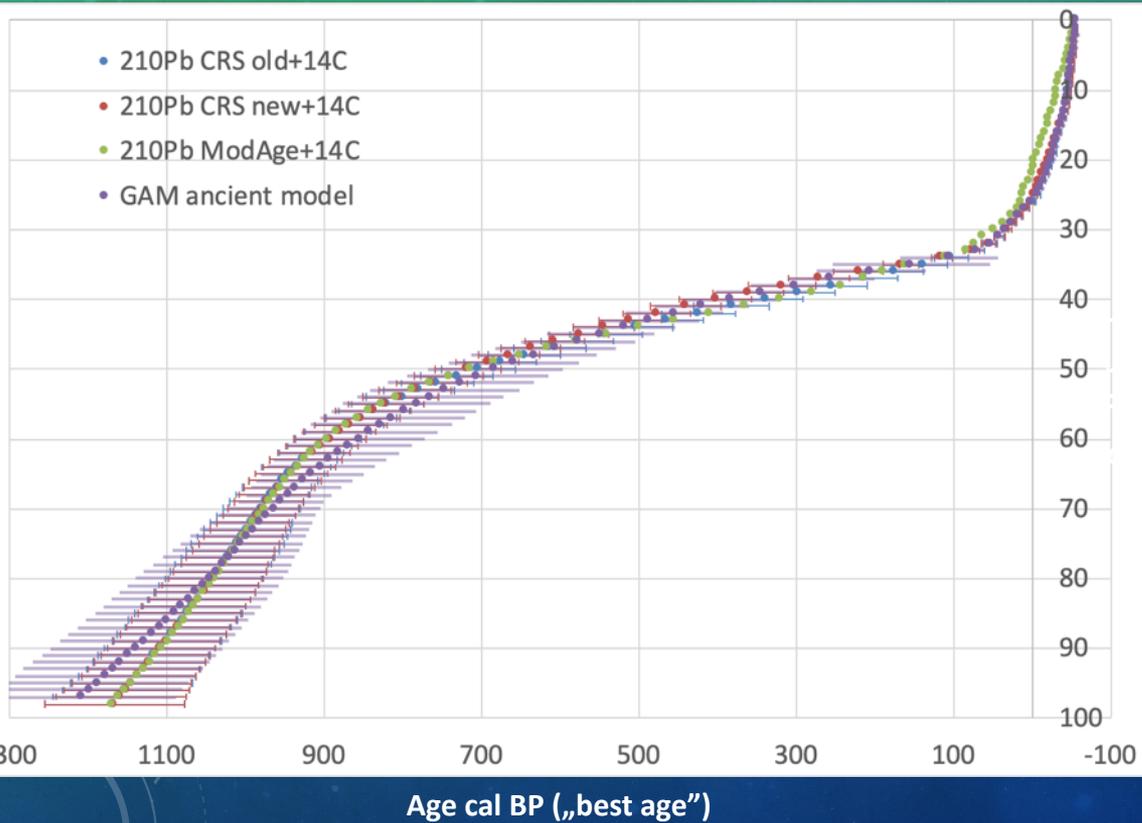
Old ^{210}Pb CRS

New ^{210}Pb CRS

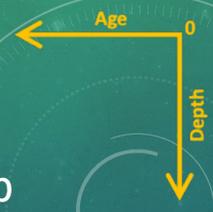
ModAge ^{210}Pb



Clam models (smooth spline) + uncertainties



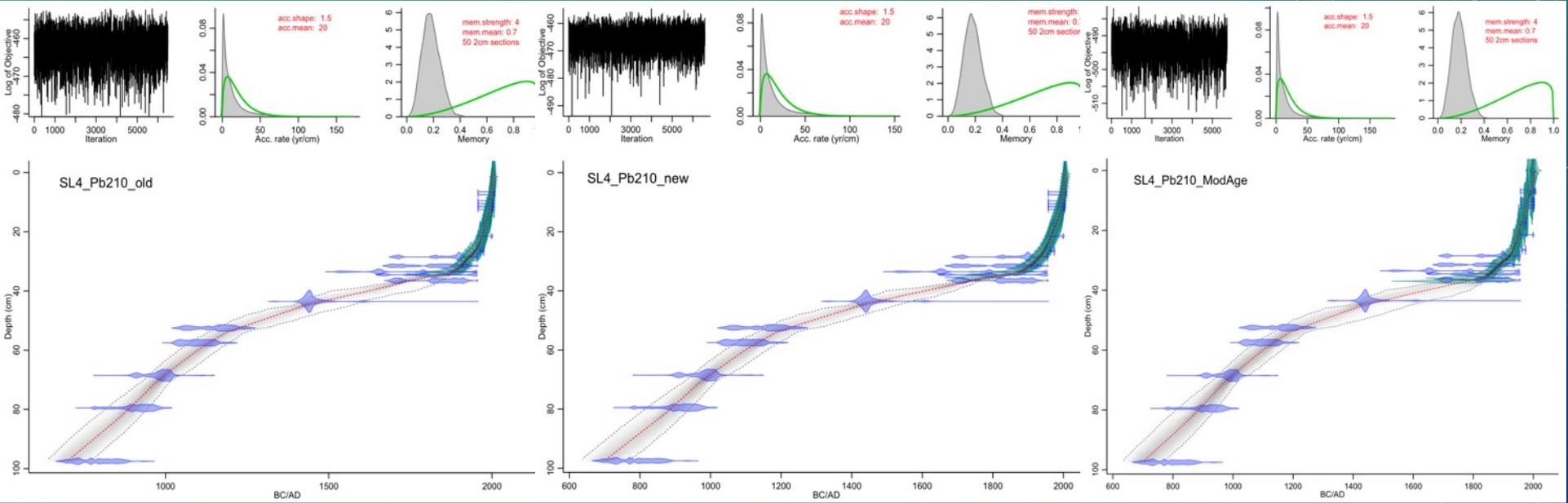
Bacon models



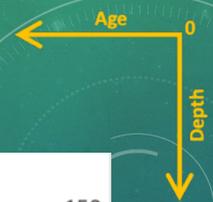
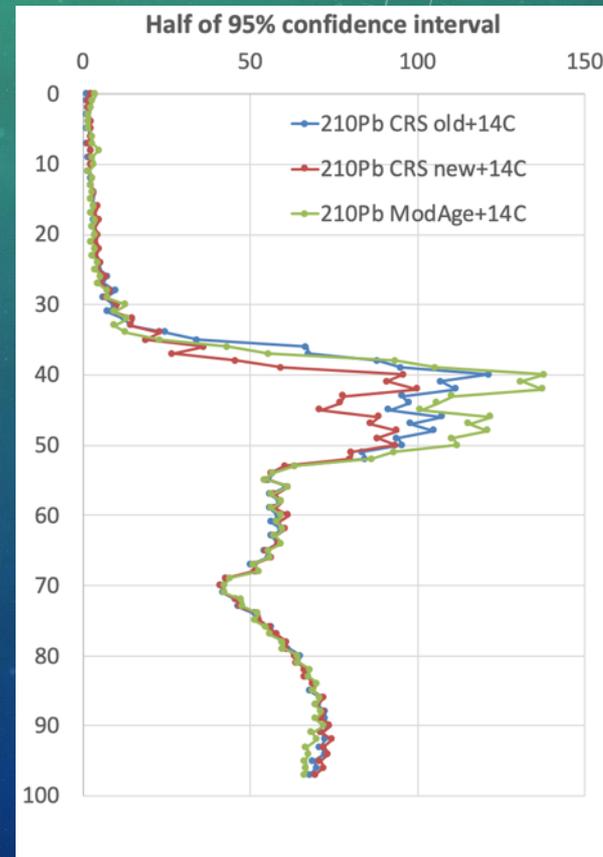
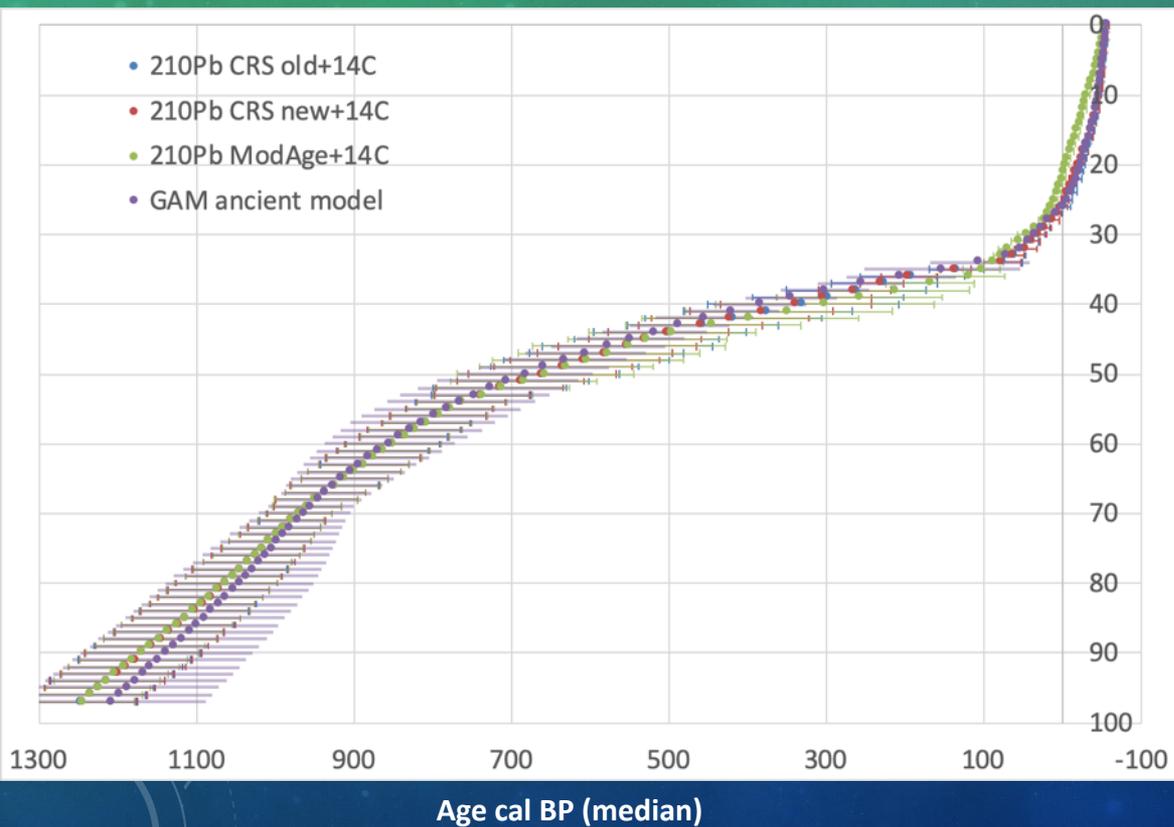
Old ^{210}Pb CRS

New ^{210}Pb CRS

ModAge ^{210}Pb

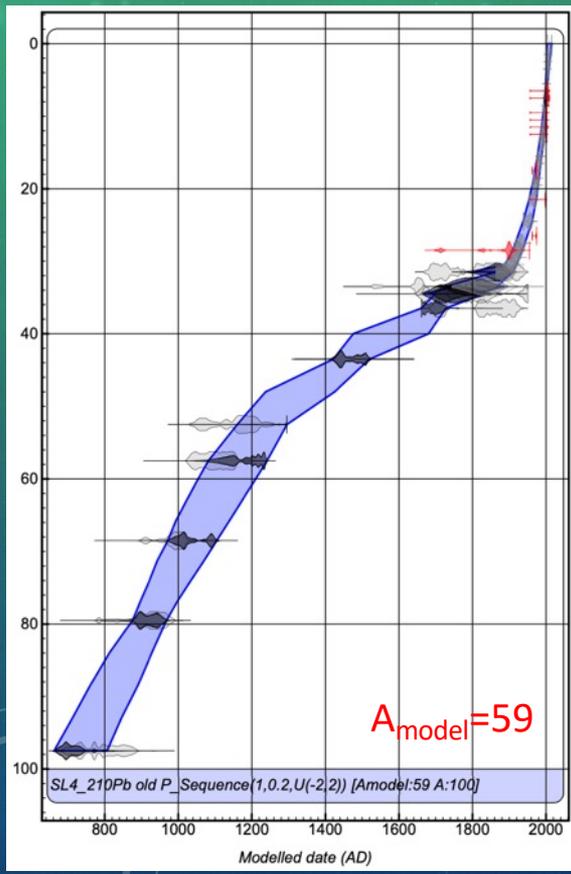


Bacon models + uncertainties

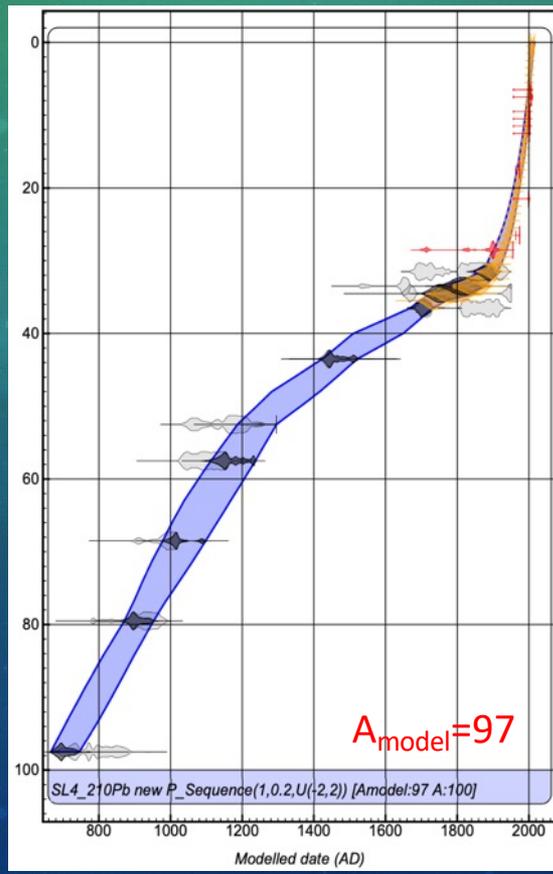


OxCal P_Sequence models

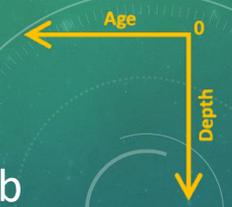
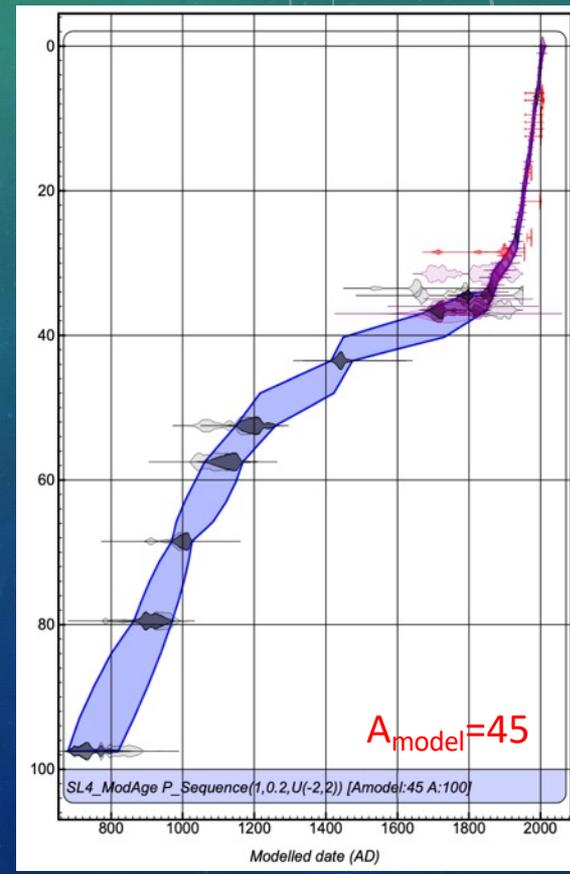
Old ^{210}Pb CRS



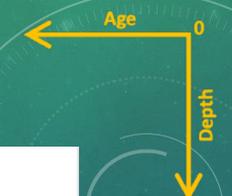
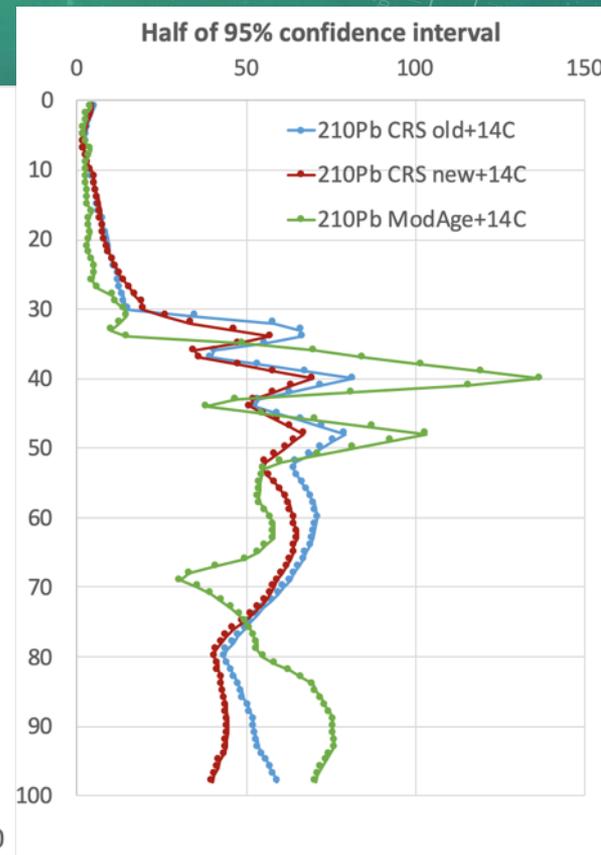
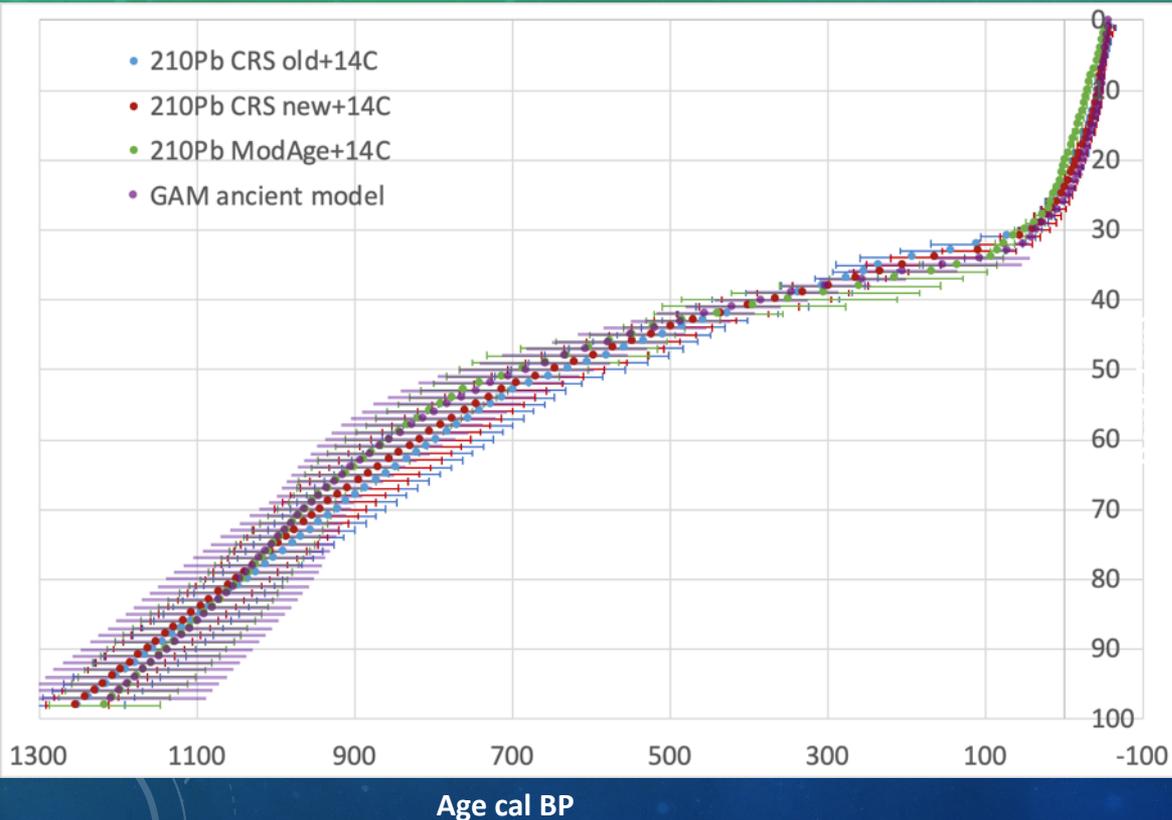
New ^{210}Pb CRS



ModAge ^{210}Pb



OxCal *P_Sequence* models + uncertainties

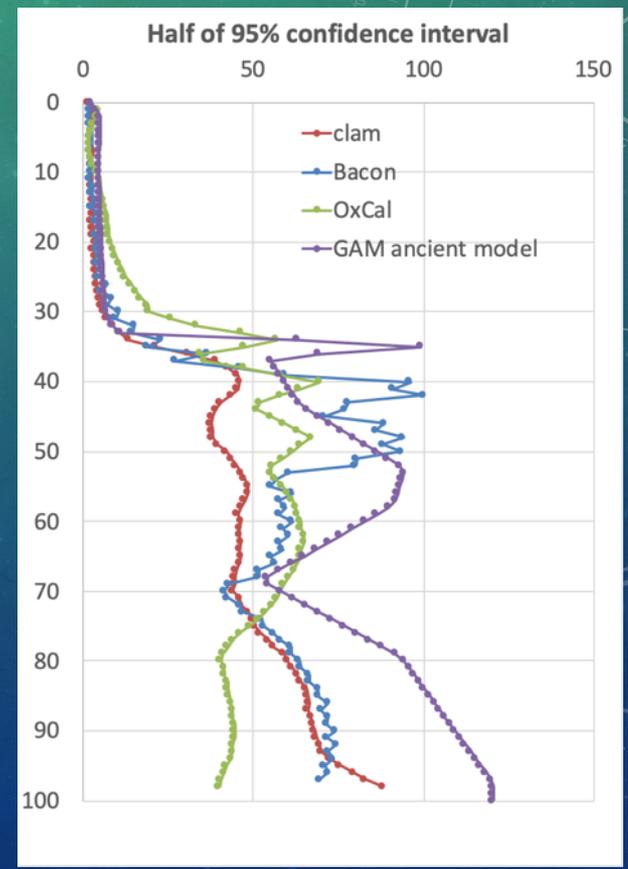
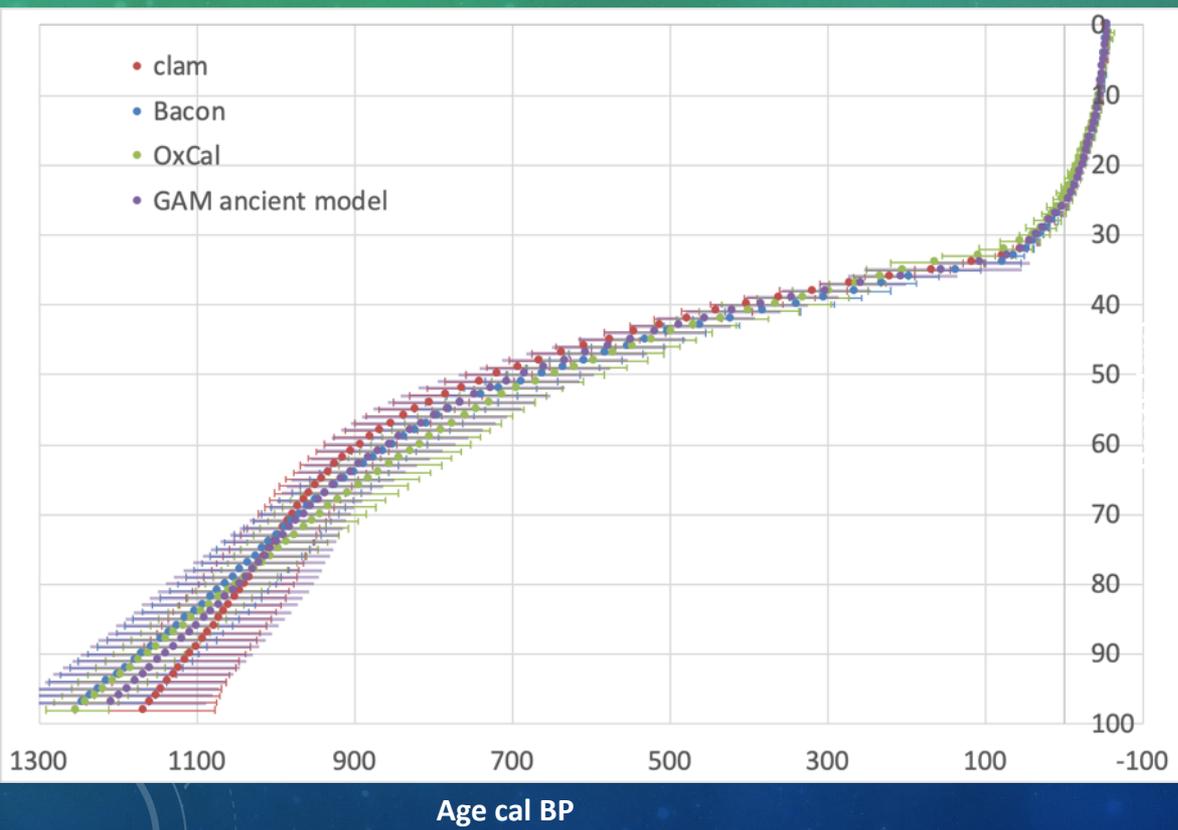
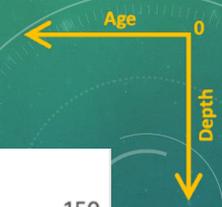


Our preferred age-depth model ;-)

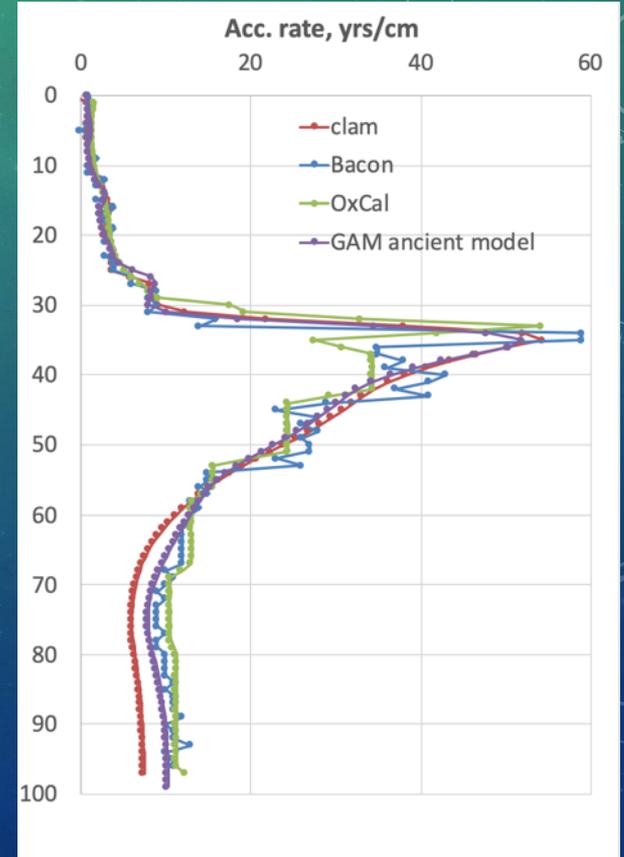
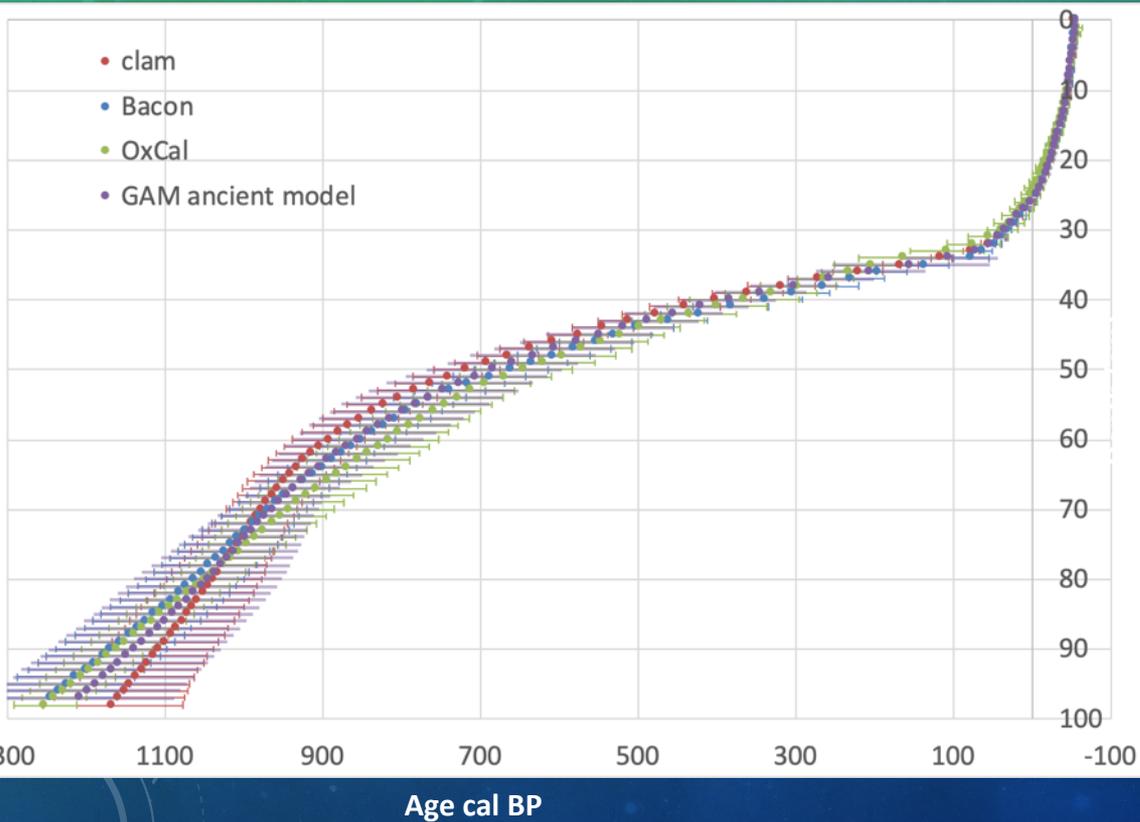
‘What the heart loves,
the will chooses, and
the mind justifies.’

ARCHBISHOP THOMAS CRANMER

New ^{210}Pb CRS models (clam, Bacon, OxCal) + uncertainties

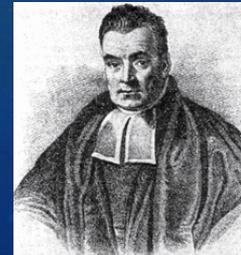


New ^{210}Pb CRS models (clam, Bacon, OxCal) + accumulation rates



Conclusions

- Different models – slightly different answers
- Sources of uncertainty
 - ^{210}Pb dates – treatment of activity
 - ^{14}C dates – modelling tool
- New Bayesian tools give better estimates of uncertainties
- Choice of dating method and age-depth tool case dependent, e.g.
 - SL2 core: ^{14}C dating only - for biological proxies and stable isotopes on *Sphagnum*
 - SL4 core: ^{210}Pb and ^{14}C for atmospheric dust reconstructions
- Acknowledgements for age modeling tools!
 - Maarten Blaauw, Andres Christen
 - Christopher Bronk Ramsey



Thomas Bayes
1701-1761

