Dates
Types of dates

No uncertainties
Yearly resolution
Decadal / centennial – (multi-) millennial resolution
Dates without uncertainties

Historical information

Dendro-dated trees

Tephra
  – But, identified with 100% confidence?
    • Geochemistry, stratigraphy
  – Depth known exactly?
Dates with annual uncertainties

Layer counting of deposits (ice, varved lakes)

$^{210}\text{Pb}$, post-bomb $^{14}\text{C}$
Annually layered ice cores

Decadal-millennial uncertainties

OSL, U/Th

$^{14}$C

- Preparation
- Contamination problems
- Measurement uncertainties
- Age offsets (spatiotemporal variation)
- Need for calibration
Bull’s Eye- Precise and Accurate
Precise but inaccurate
Accurate (on average) but imprecise
Carbon dating

14C + O2 → 14CO2

Cosmic ray produced neutrons

Algae → Shells

Fish, marine mammals

Corals

Plants

Soils

Animals

Peat

Lakes

Sediments
^14C dating

- ^14C unstable, half-life 5568 yr
- Ratio ^14C/C gives age fossil
• Atm. $^{12}\text{C}$ (99%), $^{13}\text{C}$ (1%), $^{14}\text{C}$ ($10^{-12}$)
• $^{14}\text{C}$ decays exponentially with time
• Cease metabolism → clock starts ticking
• Measure ratio $^{14}\text{C}/\text{C}$ to estimate age fossil
Dating uncertainties
$^{14}$C dating
An alternative to the normal model

- Christen and Perez 2009, Radiocarbon
- Spread of dates often beyond expected
- Reported errors are estimates
- Propose an error multiplier, gamma
- No more need for outlier modelling?
Tree-ring coverage for IntCal04: until 12.4 kcal BP

Irish Oak
Waikato
Groningen
German Oak
Pretoria
German Oak
German Oak
German Pine
Swiss Pine
Irish Oak
German Oak
Heidelberg
German Oak
PNW/CA
German Oak
German Pine
Seattle
Tree-ring coverage for IntCal04
Reimer et al., 2009. IntCal09 and marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon 51
Reimer et al., 2009. IntCal09 and marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon 51
http://www.chrono.qub.ac.uk/blaauw/
\textsuperscript{14}C calibration
$^{14}$C dating
Calibrate - methods

• Probability preferred over intercept
  – Less sensible to small changes in mean
  – Resulting cal.ranges make more sense
• Procedure probability method:
  – What is prob. of cal.year x, given the date?
  – Calculate this prob. for all cal.ages

Combine errors date and cal.curve \( \sqrt{\sigma^2 + sd^2} \)
Calibrate - methods

• Multimodal distributions
  – Which of the peaks most likely (Calib %)?
  – How report date?
    • 1 or 2 sd
    • sd range
    • mean±sd
    • mode
    • weighted mean (Telford et al. ‘05 Holocene)
    • why not plot the entire distribution!
Calibrate - DIY

- Using eyes/hands on handout paper
  - Imagine invisible arbitrary second axes for probs
  - Don't use intercept
  - Try “cosmic schwung”, not mm precision
  - Don’t go from C14 to calBP! What is prob x cal BP?
  - Calibrated ranges?