Palaeolimnologists must rethink their approach to data analysis

Gavin Simpson

Palaeo data are time series

Interest in changes in the data over time — implies the estimation of trends in data

Commonly, trend detection involves eye-balling the data

Fundamentally irreproducible — poor science

Conflates **signal** and **noise**

Victor Freitas

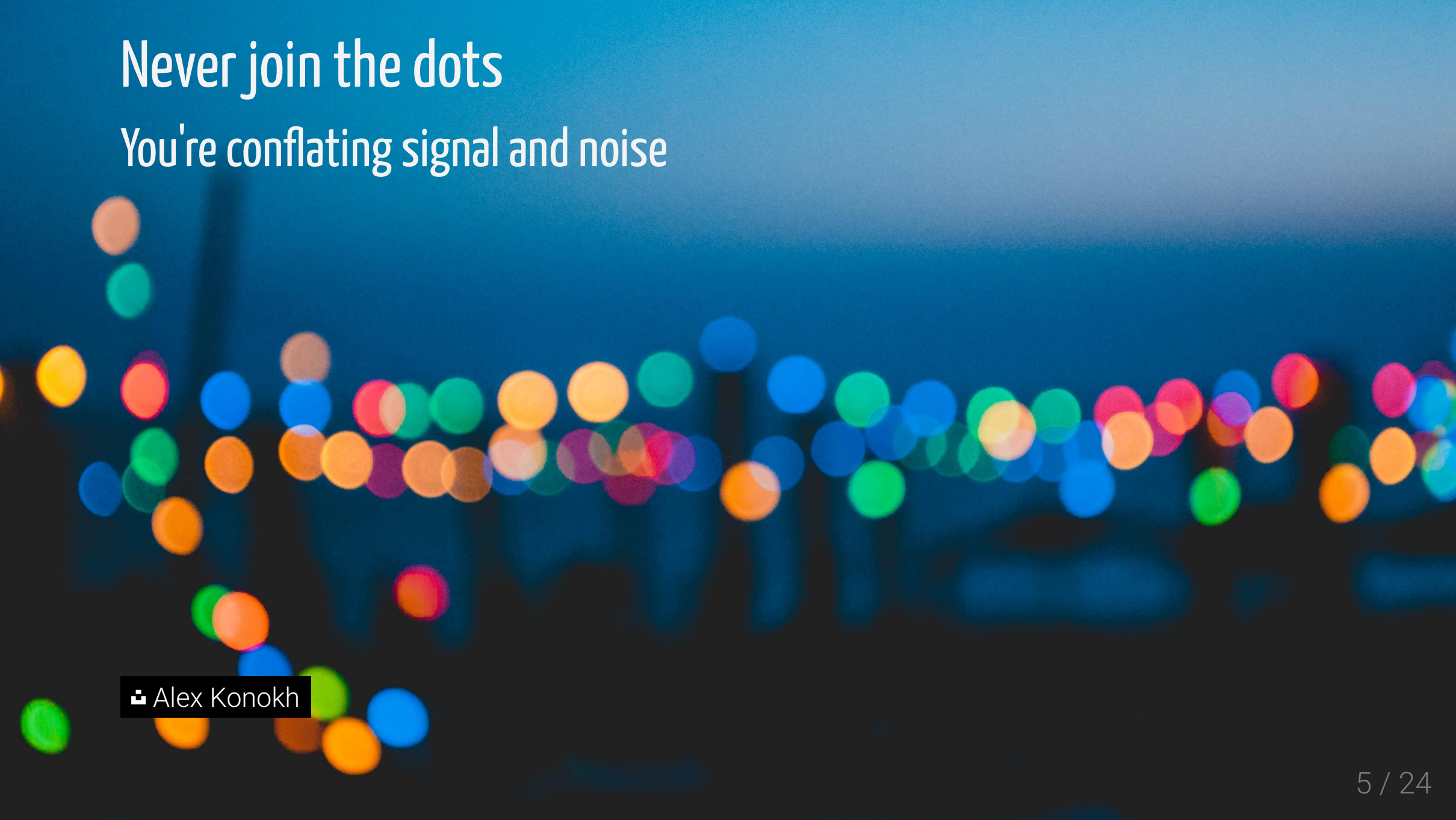
What statistical analysis is done is often wrong

NeONBRAND

Time waits for no palaeolimnologist

Never join the dots

You're conflating signal and noise



Alex Konokh

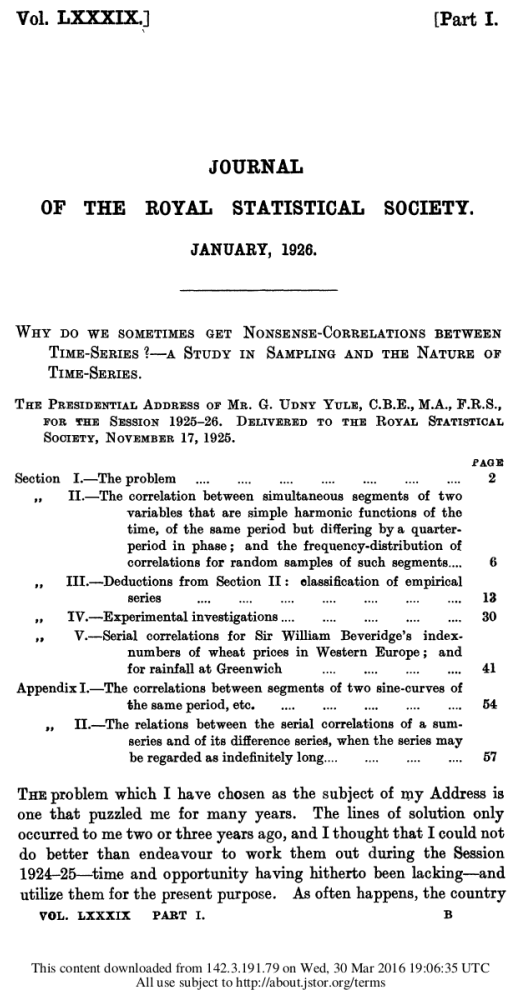
Don't correlate time series — Spurious correlation

Two time series may be correlated because

- of a their relationship with a third confounding variable
- of nothing, they're just both going up or down for no common reason

Correlation is simply a measure of the strength of association between two series

Correlation ≠ Causation



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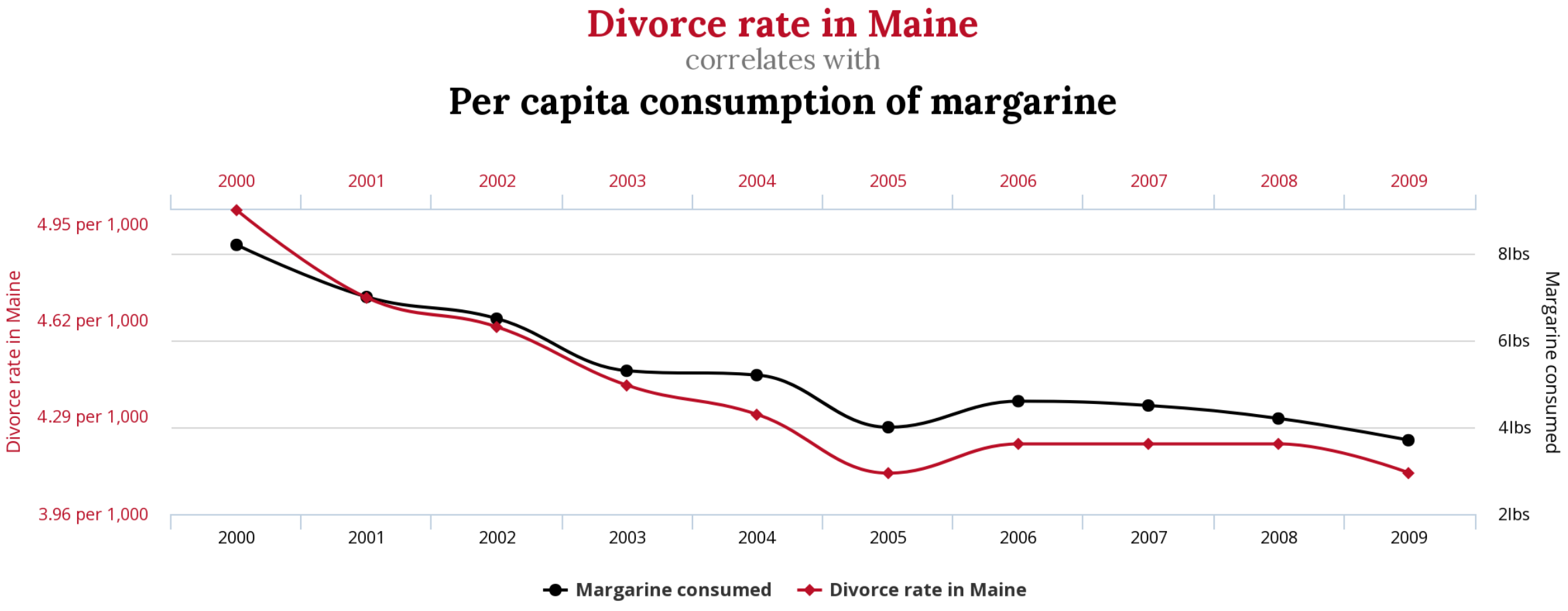


Source: Tyler Viglen www.tylervigen.com/spurious-correlations

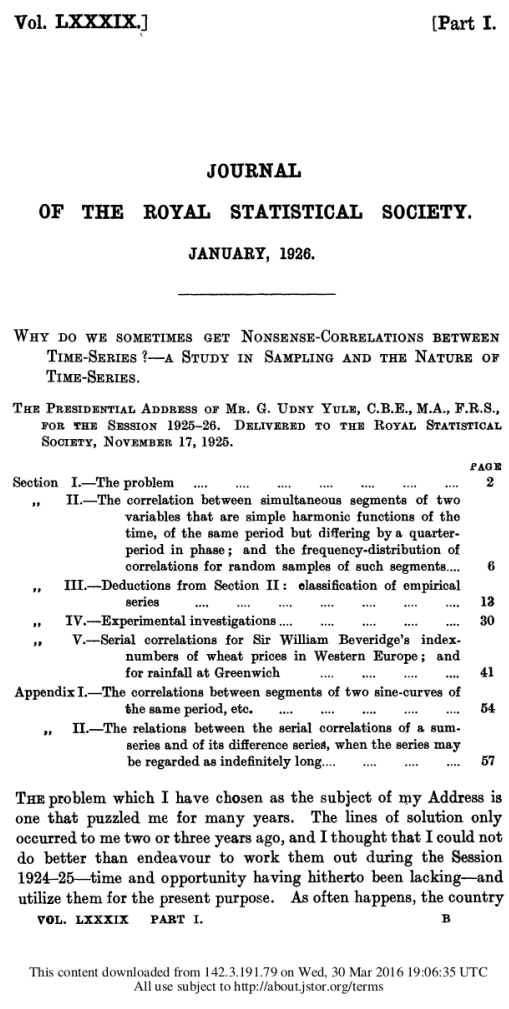
Non-parametric ≠ no assumptions

You can calculate r, ρ, or τ on time series — but what do they mean?

When you *test* r, ρ, or τ you need theory & assumptions

Key is **independent observations**

Palaeo data almost surely violate those assumptions



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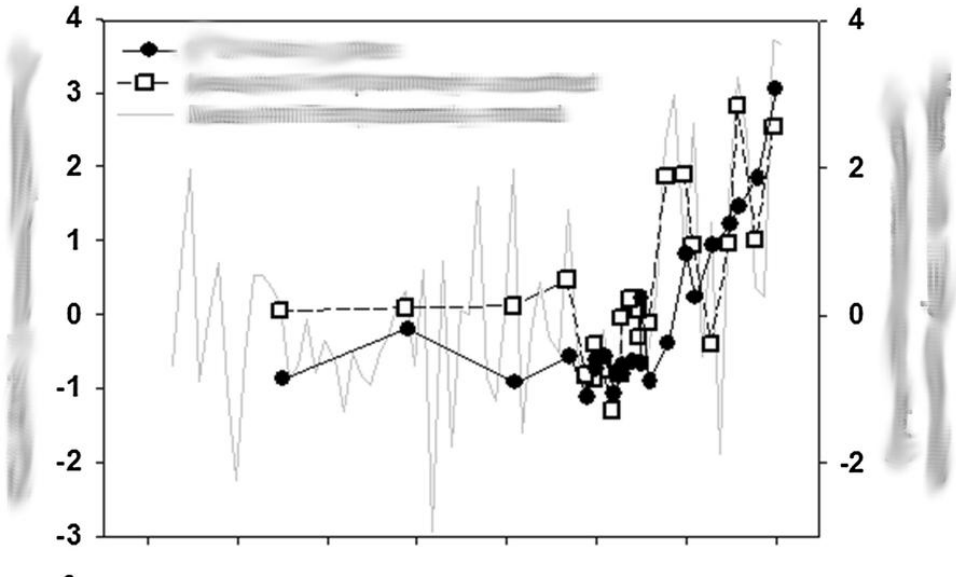
Never smooth data you input to a statistical test

Ever — not once

It makes the test result *moar significant*

You just threw away the noise!



Loess must die

Loess must die

Loess is a scatterplot smoother — for EDA

The fit is controlled by the *span*

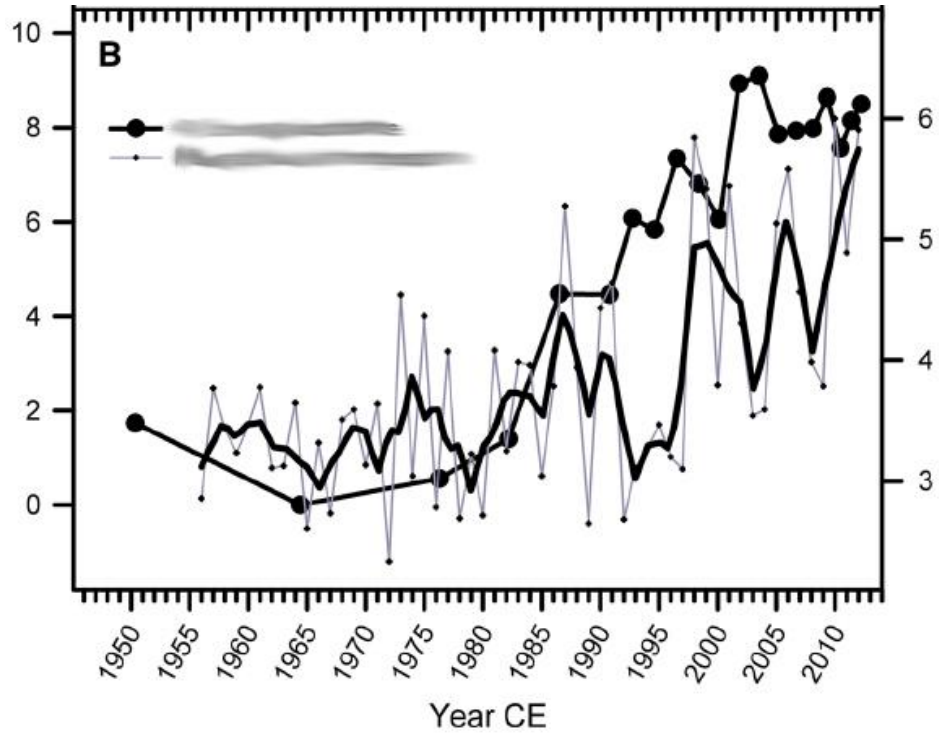
Must choose *span* appropriately

Difficult (impossible?) to do properly…

As a result often chosen subjectively!

Plain wrong — don't do it!

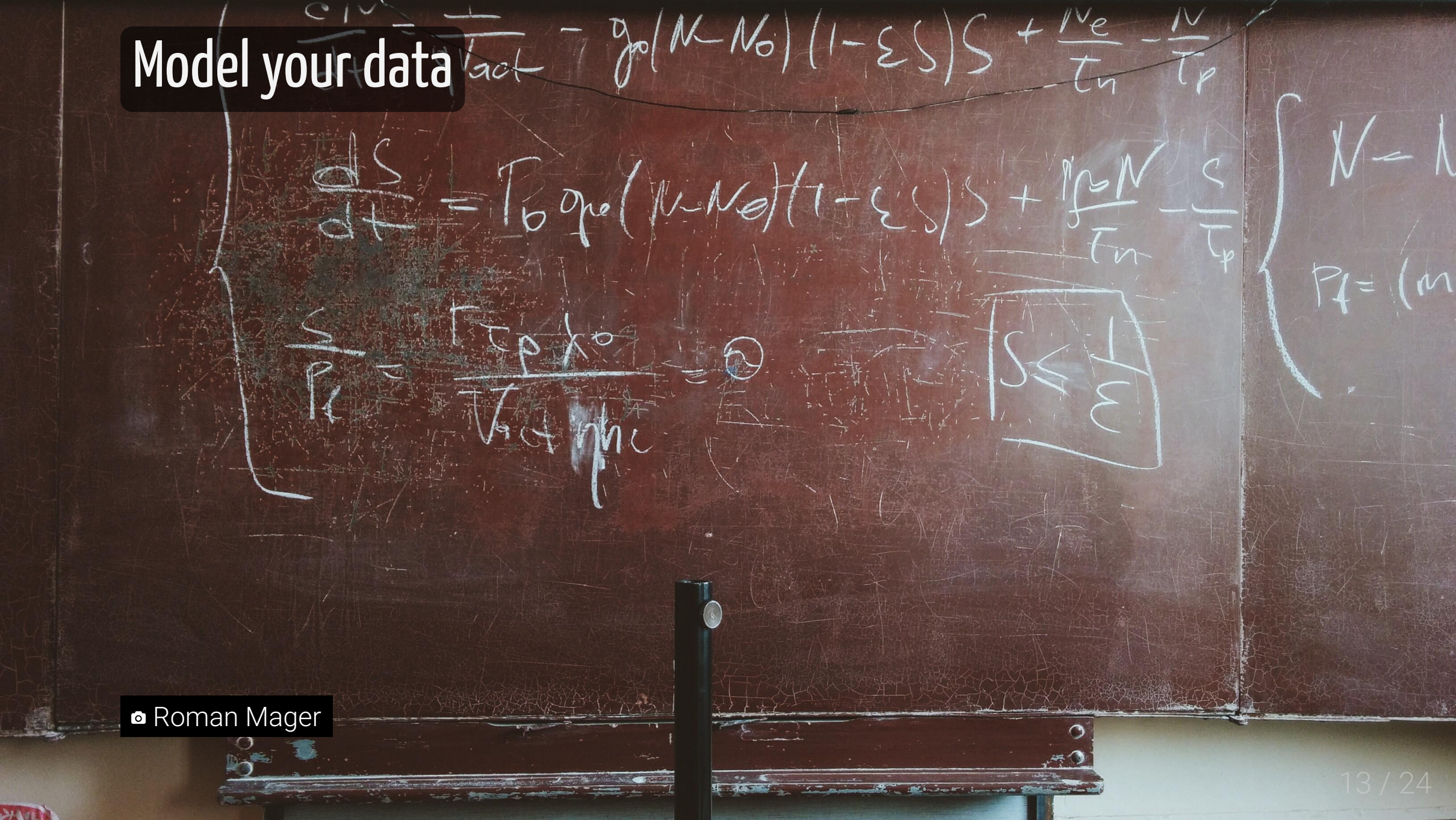
Don't use Loess for inference … exploratory data analysis only



What are we to do...?

Ross Findon

Model your data



Roman Mager

Model your data

Many models available for time series but palaeo data are often unhelpful

1. uneven spacing of observations in time (typically)
2. compaction, variable accumulation rates → non-constant variance

Can't use typical statistical time series models

But we can use generalized additive models

Generalized additive model

Linear trend model

$$\mathbb{E}(y_i) = \beta_0 + \beta_1 x_i$$

GAM

$$\mathbb{E}(y_i) = \beta_0 + f(x_i)$$

$f(\mathbf{x})$ is the trend — we assume trend is **smooth**

How do we estimate f?


WIGGLY
THINGS

Splines

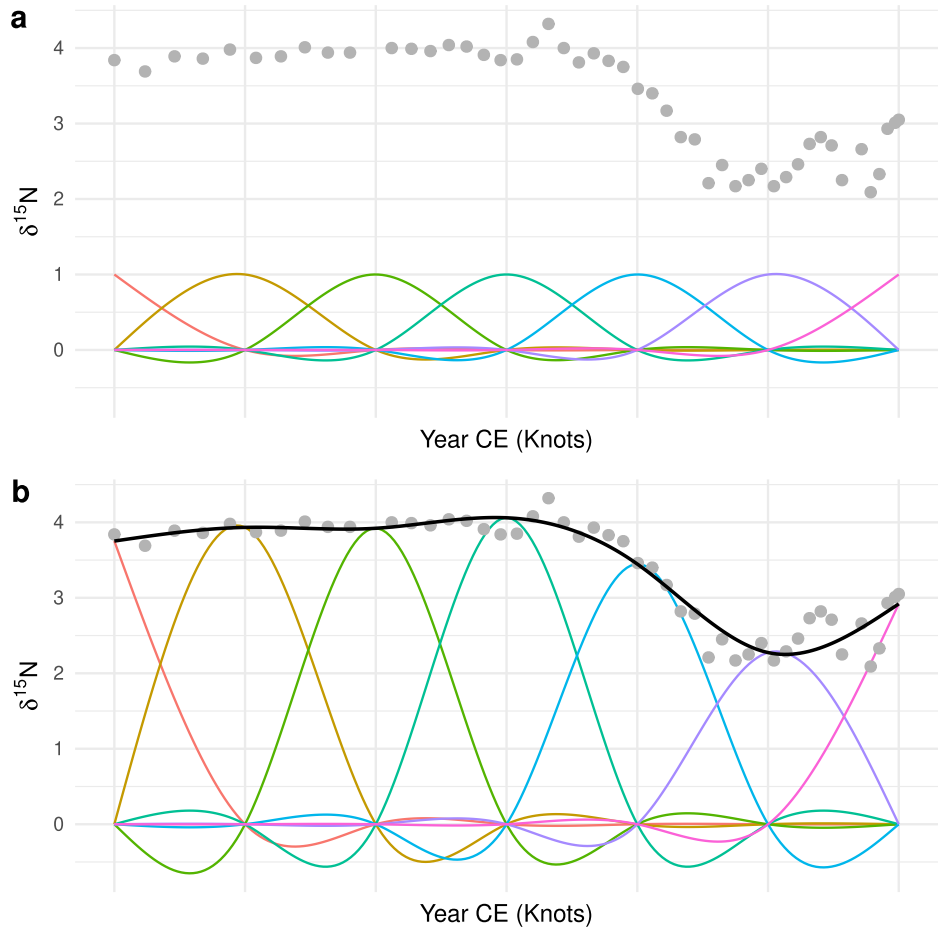
Splines are smooth functions

Made of little basis functions

Estimate β_k for each basis function

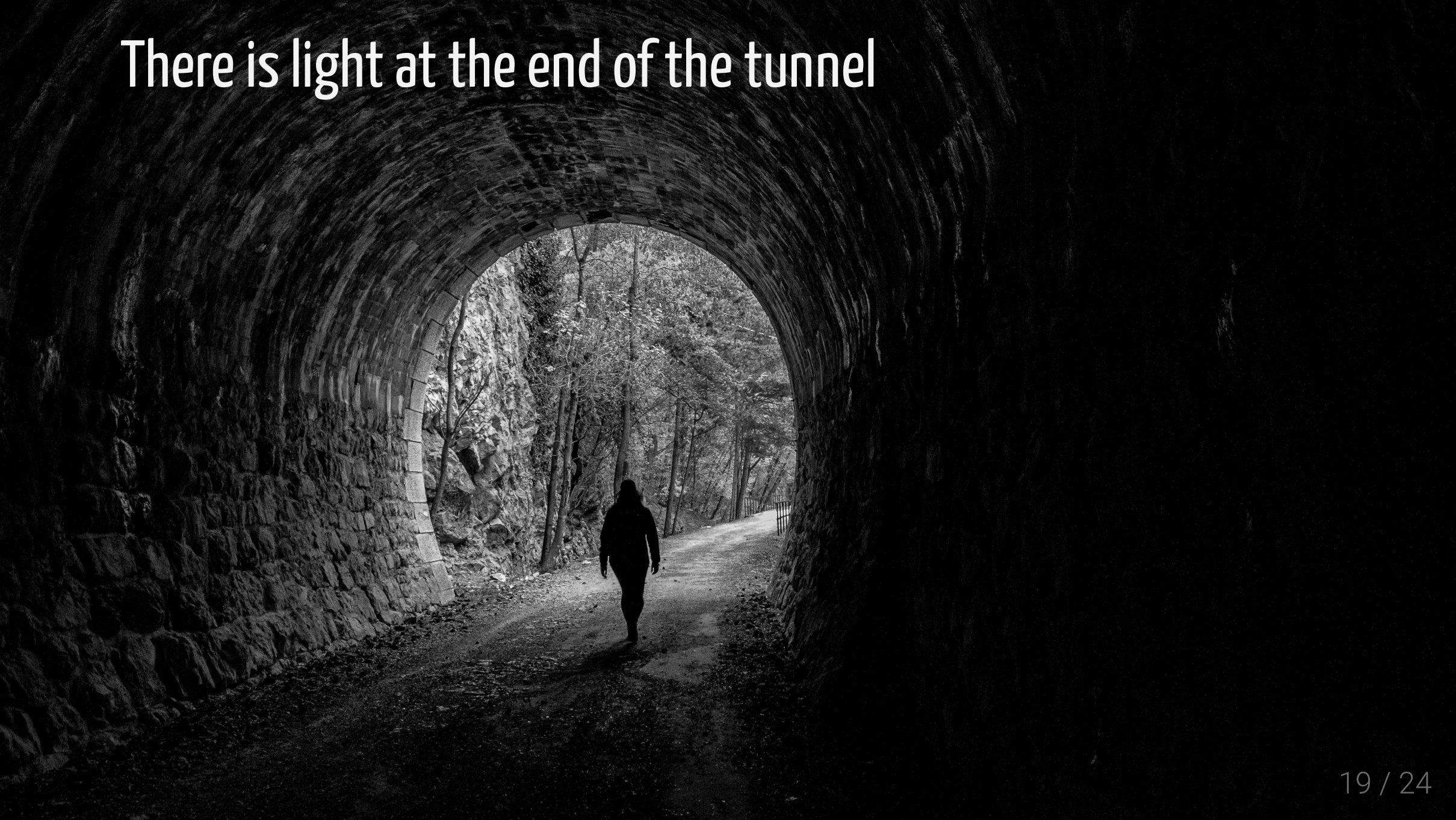
Sum the weighted basis functions at each time point

Use a penalty on **wiggliness** to avoid over-fitting



GAMs are a gateway drug

There is light at the end of the tunnel



Training

Training

Palaeolimnology was a qualitative science

Key figures dragged us into the world of quantitative palaeolimnology

Training and software were critical for this revolution

We have the software — R

A renewed need for training in modern methods

What should statistical palaeolimnology training look like?

Conclusions

Most palaeolimnological data are time series

- we're interested in estimating trends in those data
- we're interested in comparing trends between series

Rarely try to estimate those trends statistically

When we do, we often do it inappropriately

We should be modelling our data using statistical models

GAMs are a (relatively) simple model that we could use to model palaeo time series

Funding

NSERC
CRSNG

Want to know more...?

Paper — doi:10/gfrc4p

Blog — www.fromthebottomoftheheap.net

Slides — bit.ly/pals-stats