

Generalized Additive Mixed Models (GAMMs)

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(adapted from Kyle Edwards lectures and Simon Wood
textbook)

Agenda

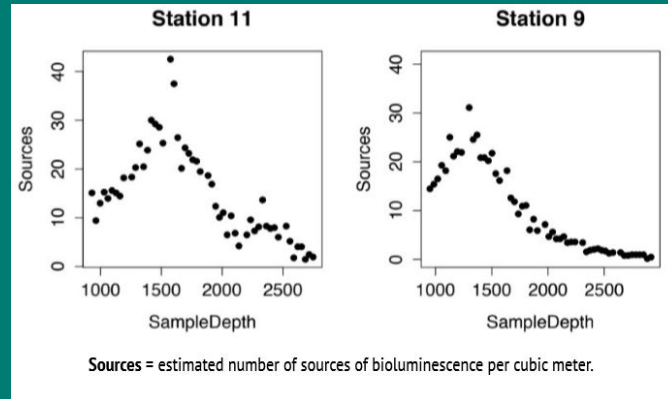
1. Brief review of when to use GAMs and mixed models
2. What is a GAMM?
3. Examples of when GAMMs are useful
4. Examples in R

Recall : GAMs

Generalized additive models (GAMs) are used for modeling **nonlinear relationships** without using a specific formula to relate x and y

GAMs are **data-driven** rather than equation-driven.

Involves fitting spline curves by piecing together different functions (e.g cubic polynomials)



Recall: When to use a mixed model?

You suspect that **random variables** are contributing to the relationship between your experimental (fixed) variables

Example sources of random variability (must be factors, not continuous):

- Repeated measures made on the same individuals
- Measurements are made on clusters of related individuals
- Result of one measurement depends on result of a previous measurement (e.g. growth over time)

Note: Random effects can help explain non-independence in data, but relationships should not be interpreted unless there are enough observations within each random effect (e.g. ICC)

What is a GAMM?

A GAMM is a GAM where random effects are accounted for.

Kyle Edwards definition: “[GAMMs] allow nonlinear predictors while also including random effects to account for spatiotemporal structure, etc.”

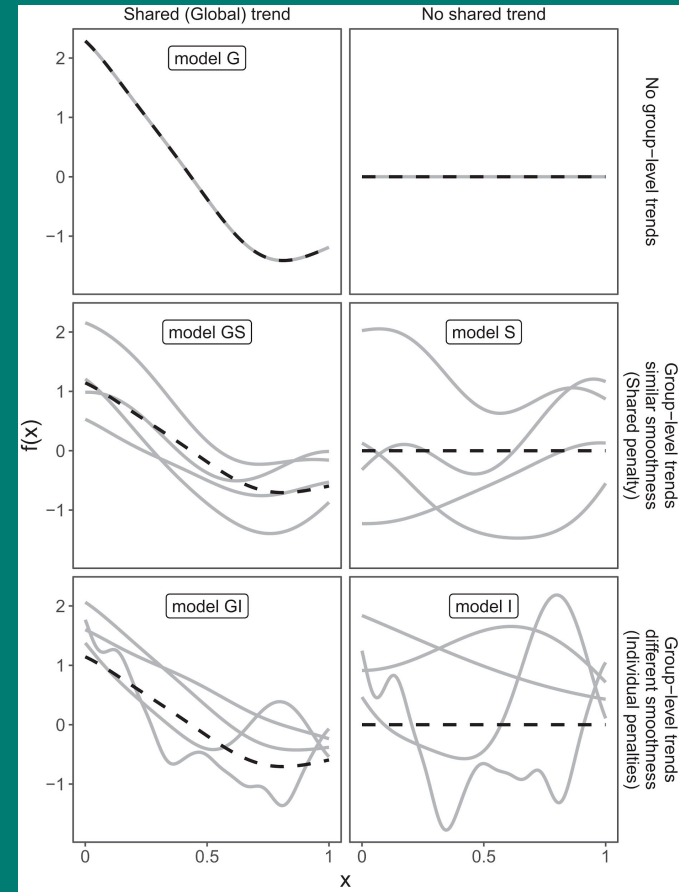
There are multiple functions to fit random effects in GAMMs

GAMMs are a new and developing technique! (best practices are still being decided...)

Note: Most ecological GAMM examples I've seen use GAMM to account for spatiotemporal random effects. Has anyone used a GAMM for something different?

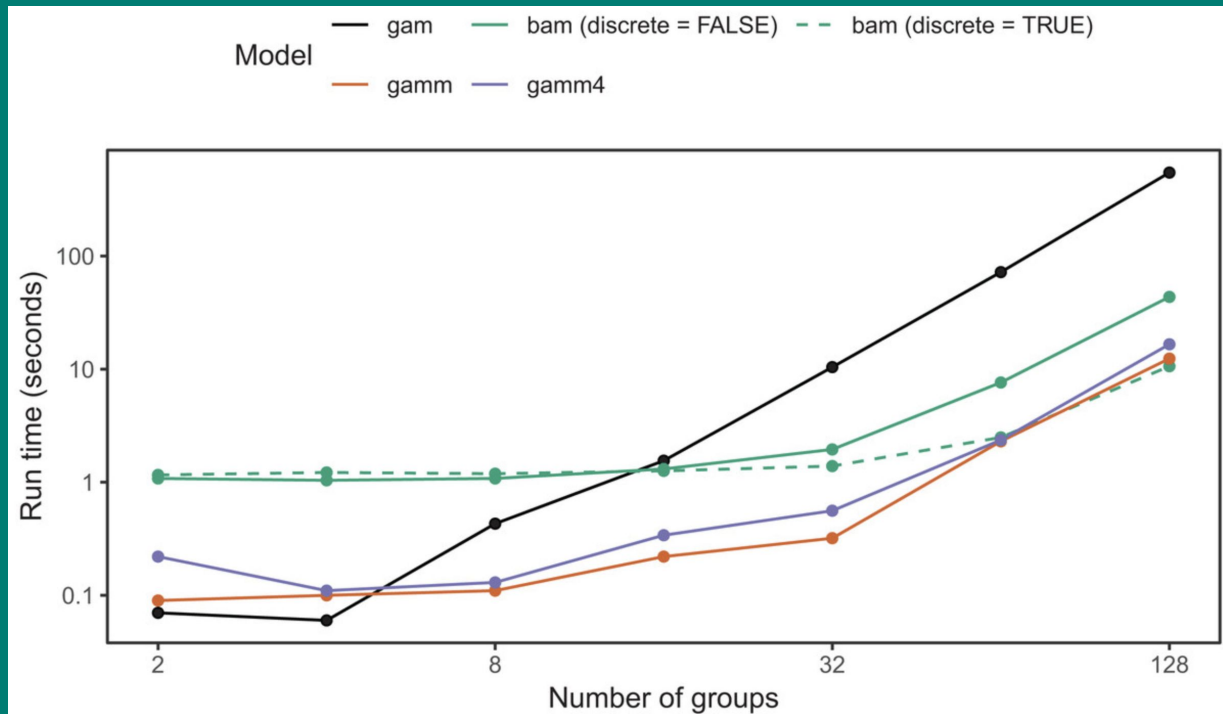
GAMMs are very similar to GAMs

The only difference is that now you can choose clustering of smoothers and wiggleness based on random effects



Different functions to fit random effects, all computationally heavy

Pick your framework based in how complex your data are



GAMMs are useful when...

Scenario #1: You have data on individuals from different groups (where group is a random effect; e.g. site) and you suspect there is a **group effect** contributing to your observed non-linear relationship.

Example: You are studying the spatial structure of coyote-wolf hybridization across many populations, and you need to account for individuals sampled from the same population having similar ancestry.

- Using a GAMM, you can get random effect estimate for Pack ID#, random effect variances for all smoothers, and fixed effects estimates for smoothers
- Mathematically, each smoother is estimated in terms of a random effect variance that quantifies how nonlinear the smoother is

GAMMs are useful when...

Scenario #2: You want to **decompose** a variable while accounting for correlated random effects

Example: You are working with long term time series data. You want to look at both the overall change over time as well as non-linear fluctuations that happen each year.

- When decomposing into yearly fluctuations, “year” can be included as a random effect to account for year-to-year variability.

Keep in mind...

Make sure you can **biologically explain** your random effects!

This is particularly important when using additive models. We can fit any curve that appears to describe the data, so it is really important to be able to biologically interpret and justify these relationships!

Resources

Awesome book on non-linear modeling:

https://www.amazon.com/Generalized-Additive-Models-Introduction-Statistical-ebook-dp-B006WEFAX0/dp/B006WEFAX0/ref=mt_ot her?_encoding=UTF8&me=&qid=

Tutorials and more background information:

<https://m-clark.github.io/generalized-additive-models/introduction.html>

<https://highstat.com/index.php/beginner-s-guide-to-generalized-additive-mixed-models>

http://rstudio-pubs-static.s3.amazonaws.com/9009_7c82e40c3c964720811391da761cf70e.html

https://www.casact.org/education/rpm/2015/handouts/Paper_3983_handout_2437_0.pdf <- a nice summary of almost everything we've talked about in GLAMM this summer

Literature that uses GAMM:

1. Knappe, Jonas. "Decomposing trends in Swedish bird populations using generalized additive mixed models." *Journal of Applied Ecology* 53.6 (2016): 1852-1861.
2. Cabrera, M., and G. Taylor. "Modelling spatio-temporal data of dengue fever using generalized additive mixed models." *Spatial and spatio-temporal epidemiology* 28 (2019): 1-13