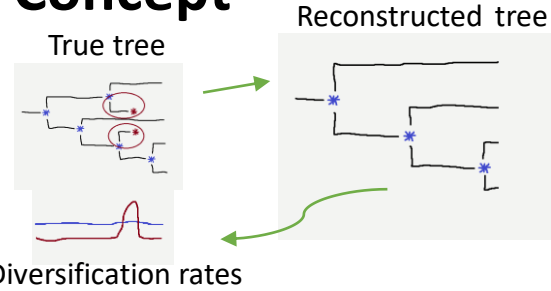


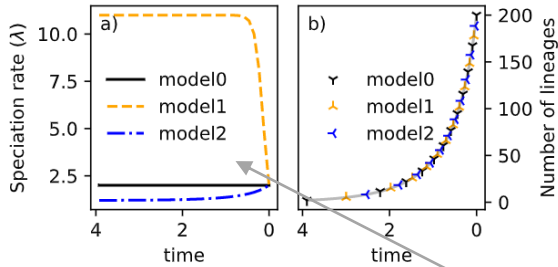
# Congruent birth-death models can be collapsed using Bayesian inference

## Concept



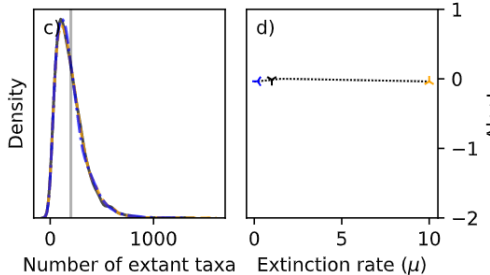
## Problem: congruent models

Explained by Louca & Pennell [1]



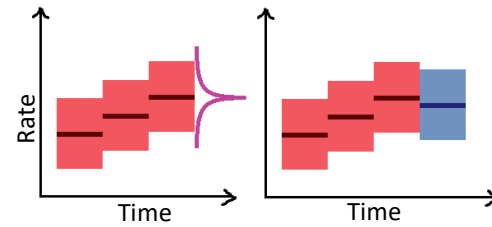
### Properties

- Equal likelihoods
- Produce equal reconstructed trees



## Proposed solution:

### Temporal smoothing



Use a **prior** that favors less change over more change

## Constructing congruent models

Start with constant-rate model ( $\mu_0, \lambda_0$ )

1. Pick  $\mu_1$
2. Construct  $\lambda_1$ :

$$\lambda(\tau) = \frac{\rho\lambda_0 e^{(\lambda_0 - \mu_0 + \mu_1)\tau}}{\rho + \frac{\rho\lambda_0}{\lambda_0 - \mu_0 + \mu_1} (e^{(\lambda_0 - \mu_0 + \mu_1)\tau} - 1)}$$

3. A set of congruent models

model	$\lambda(\tau)$	$\mu$
model0	2	1
model1	$\frac{2e^{11\tau}}{1 + \frac{2}{11}(e^{11\tau} - 1)}$	10.0
model2	$\frac{2e^{1.2\tau}}{1 + \frac{2}{1.2}(e^{1.2\tau} - 1)}$	0.2

Constant  
 Decreasing  
 Increasing

### References

- [1] Louca, S., & Pennell, M. W. (2020). Extant timetrees are consistent with a myriad of diversification histories. *Nature*  
 [2] Höhna, Landis, Heath, Boussau, Lartillot, Moore, Huelsenbeck, Ronquist. 2016. RevBayes: Bayesian phylogenetic inference using graphical models and an interactive model-specification language. *Systematic Biology*  
 [3] Magee, A. F., Höhna, S., Vasylyeva, T. I., Leaché, A. D., & Minin, V. N. (2020). Locally adaptive Bayesian birth-death model successfully detects slow and rapid rate shifts. *PLoS computational biology*

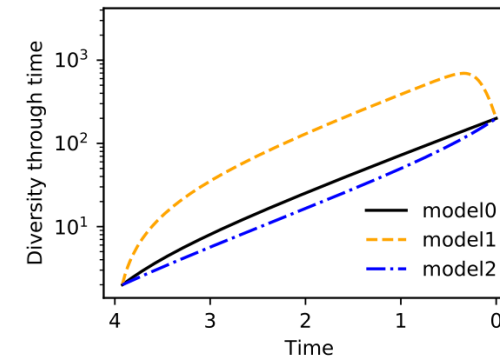
## Simulation study

1. Simulate 100 trees
2. Fit Bayesian model in RevBayes [2, 3]
3. Summarize results

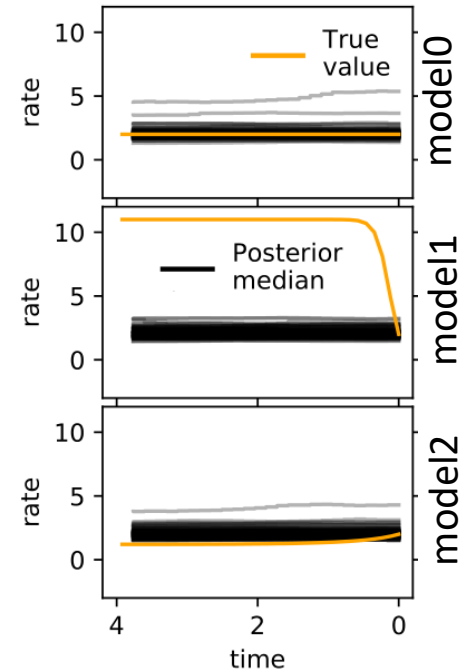
We recover the “simpler” model. The model is still not identifiable, but we recover one model and not a random choice

## Results

- Constant-rate model recovered
- Increasing & decreasing **not recovered**
- Congruence class collapsed



### speciation



## Ideas

- Lineage-through-time curve is equal. Diversity-through-time is not!
- Can use paleontological evidence to corroborate, and “shrink” congruence class