A new phylogenetic comparative method: detecting niches and transitions with continuous characters.

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UC Davis

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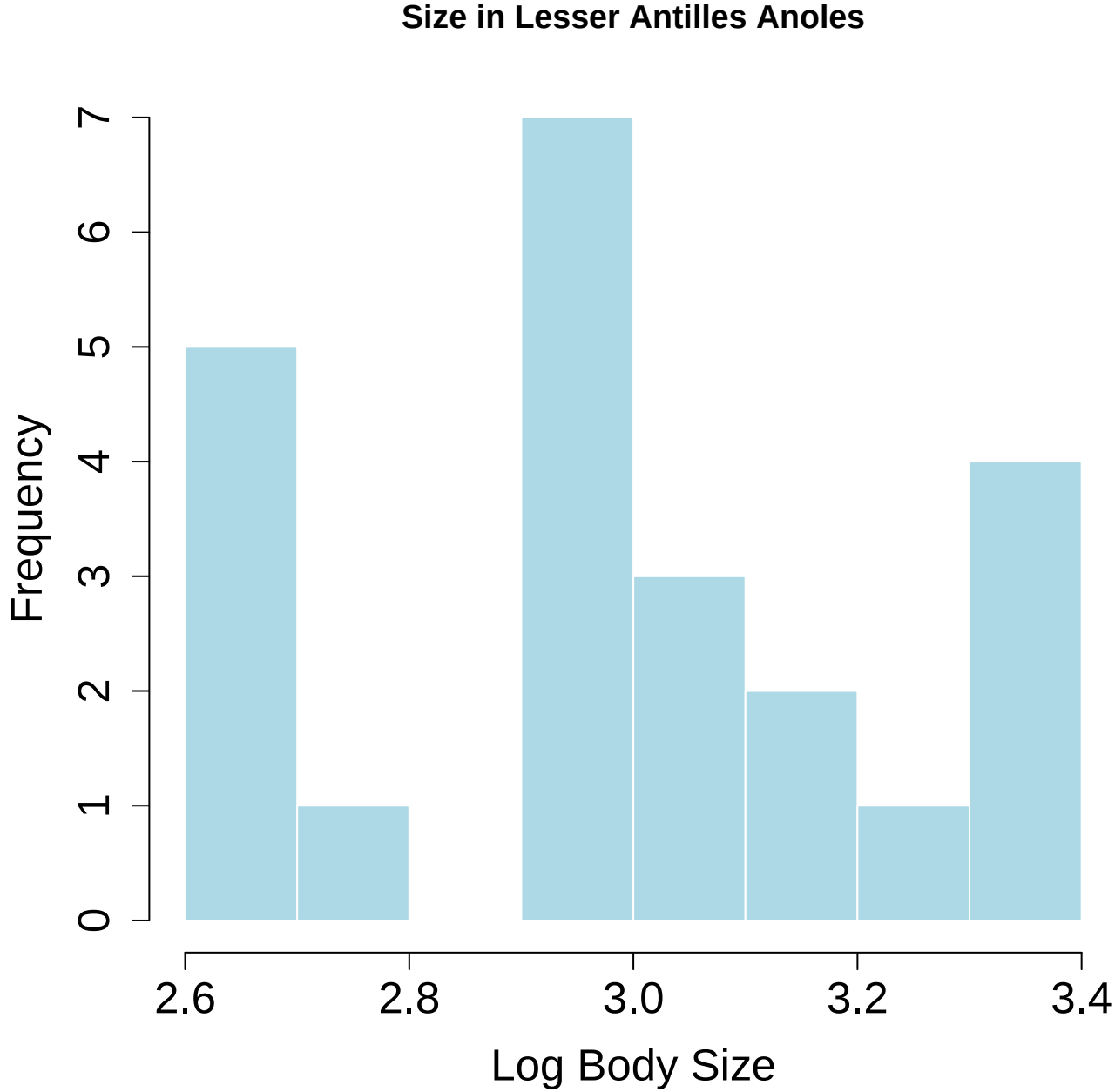
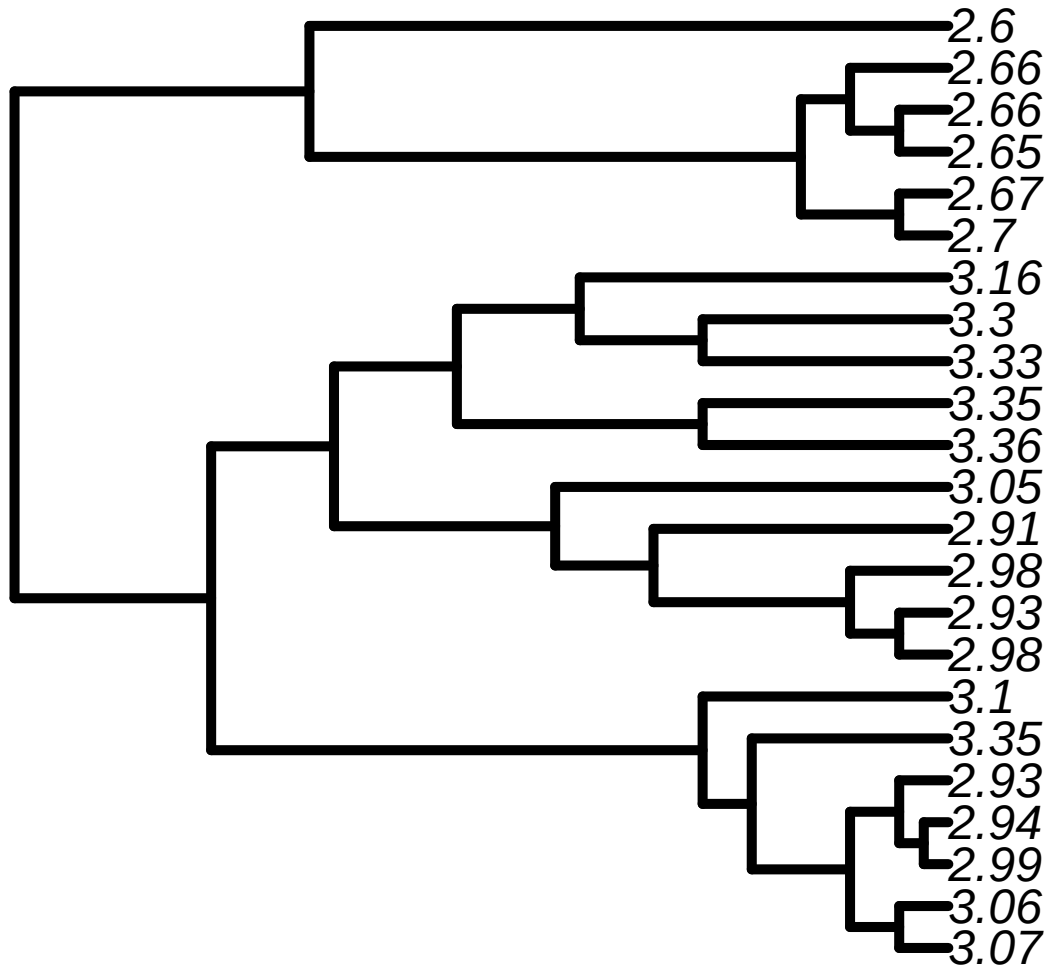

Size in Lesser Antilles Anoles
Frequency
0
1
2
3
4
5
6
7
2.6
2.8
3.0
3.2
3.4
Log Body Size


2.6
2.66
2.66
2.65
2.67
2.7
3.16
3.3
3.33
3.35
3.36
3.05
2.91
2.98
2.93
2.98
3.1
3.35
2.93
2.94
2.99
3.06
3.07

Goals

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1. Demonstrate selecting models by information criteria is inadequate

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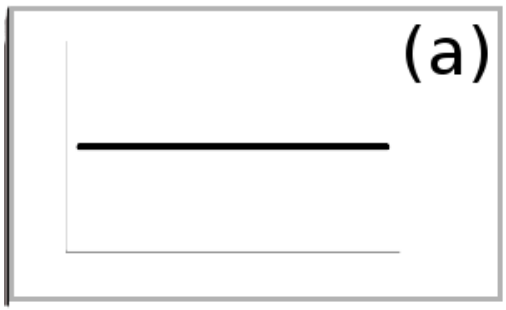
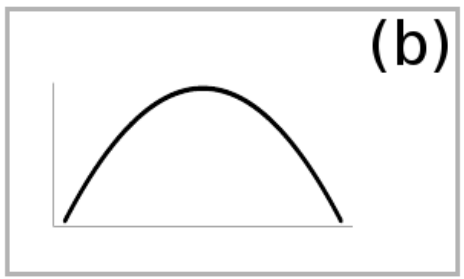
2. I'll propose a more robust framework

Types of models



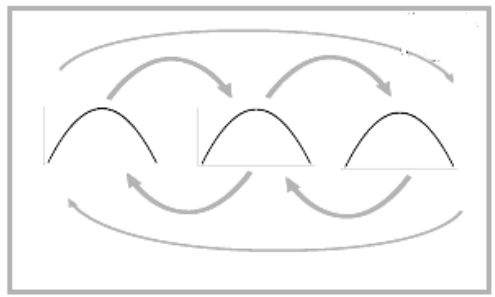
Brownian Motion

$$dX = \sigma dB$$



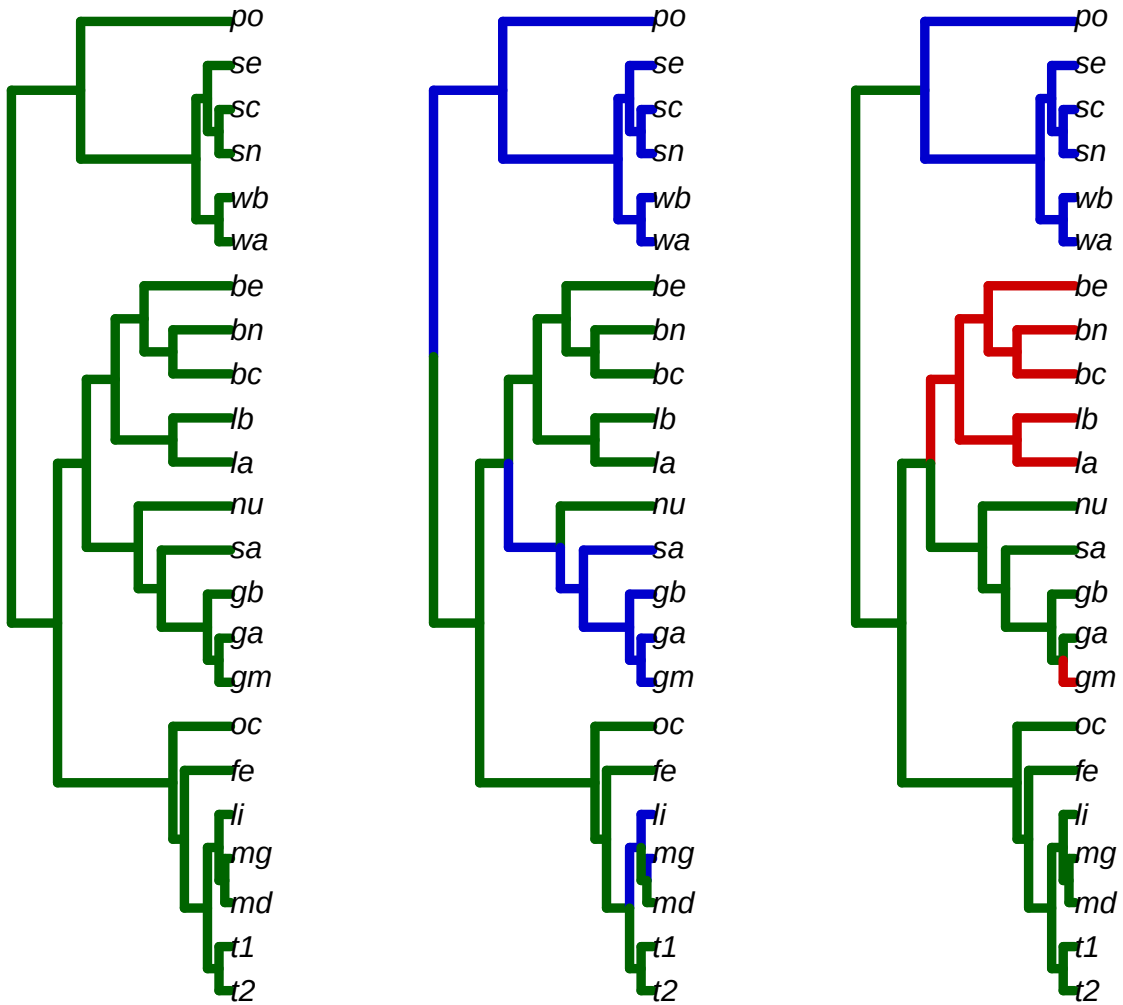
Ornstead-Uhlenbeck

$$dX = \alpha(\theta - X)dt + \sigma dB$$

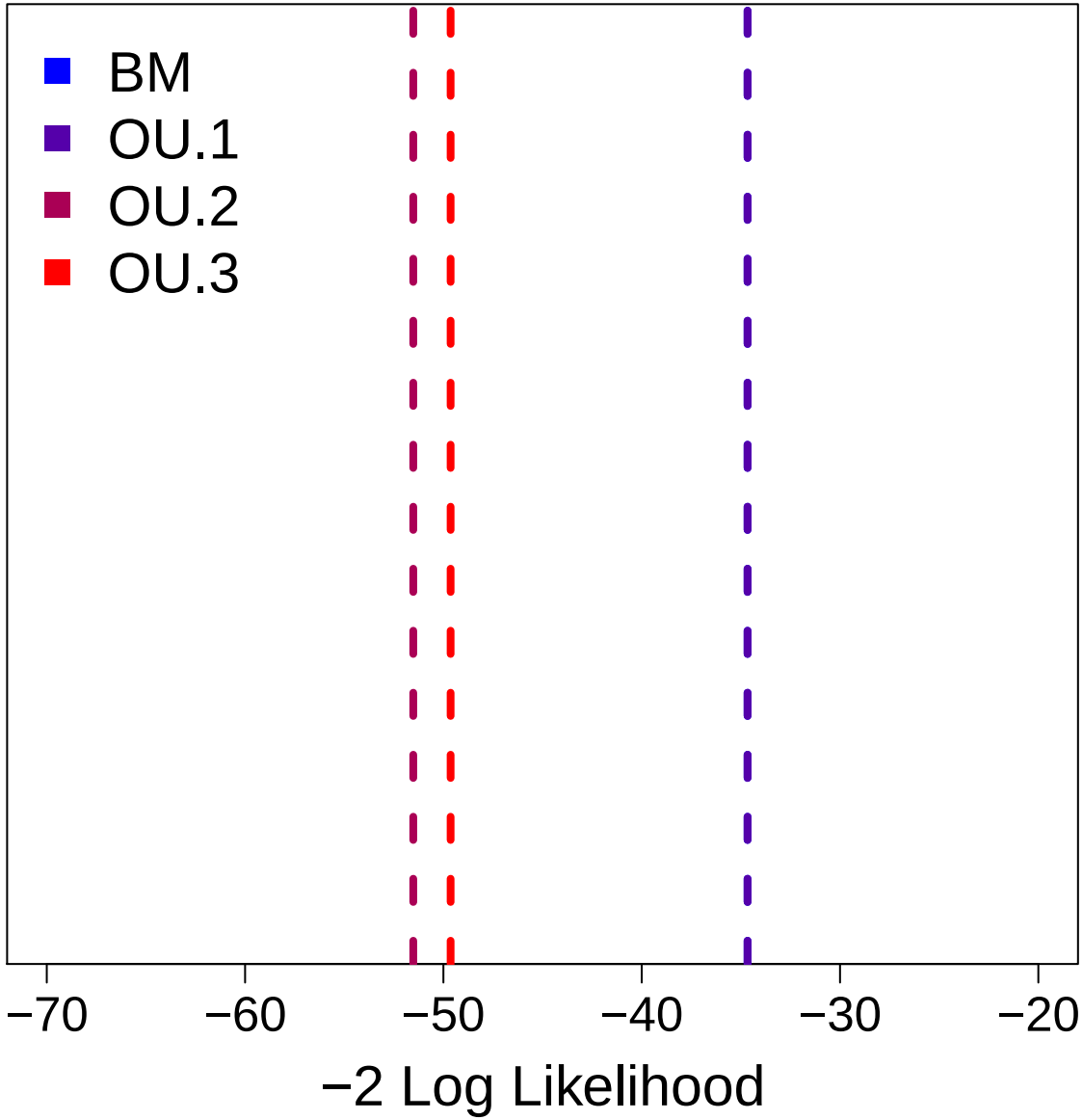


Regimes

Comparing Models

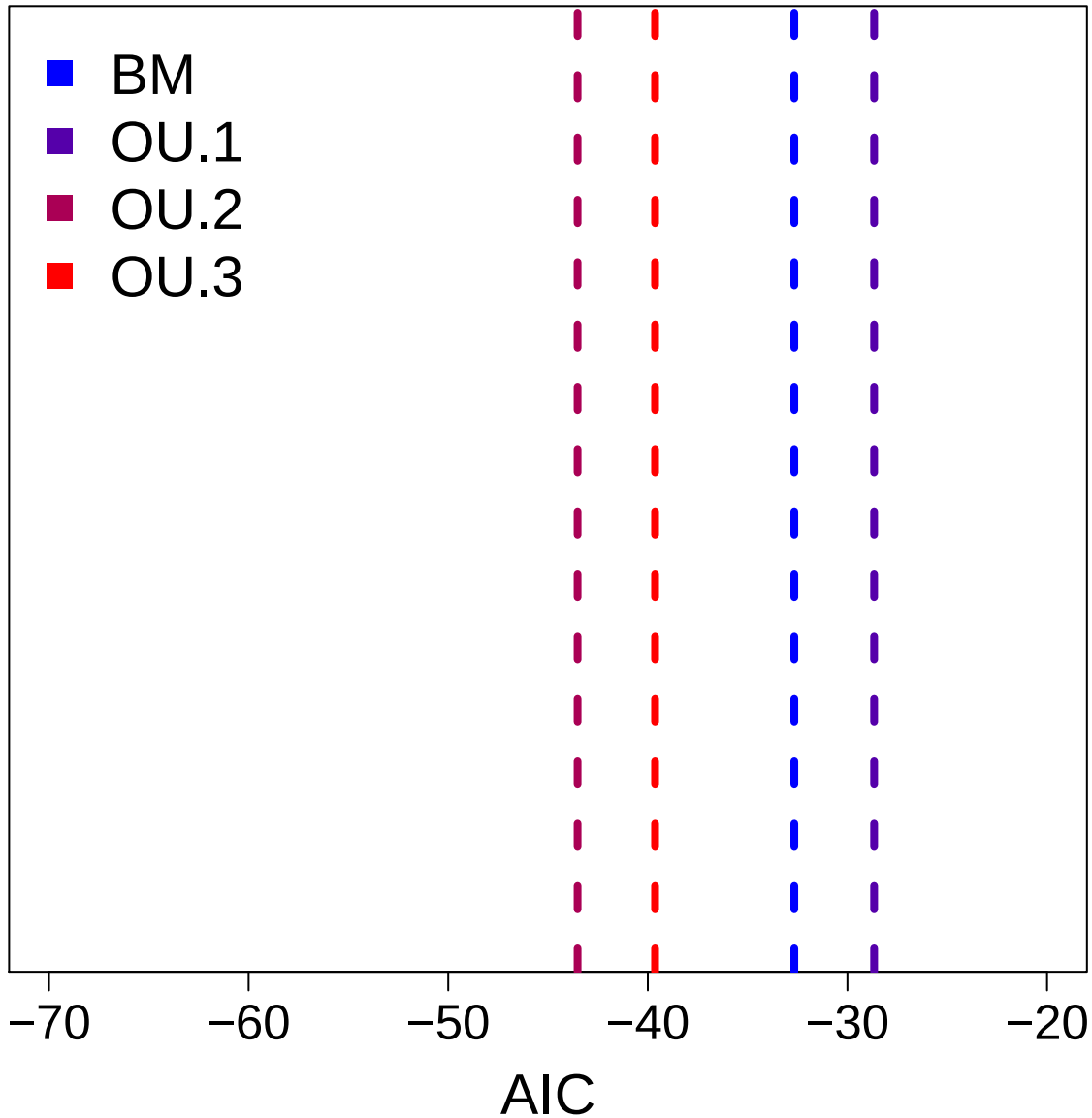


Comparing Models



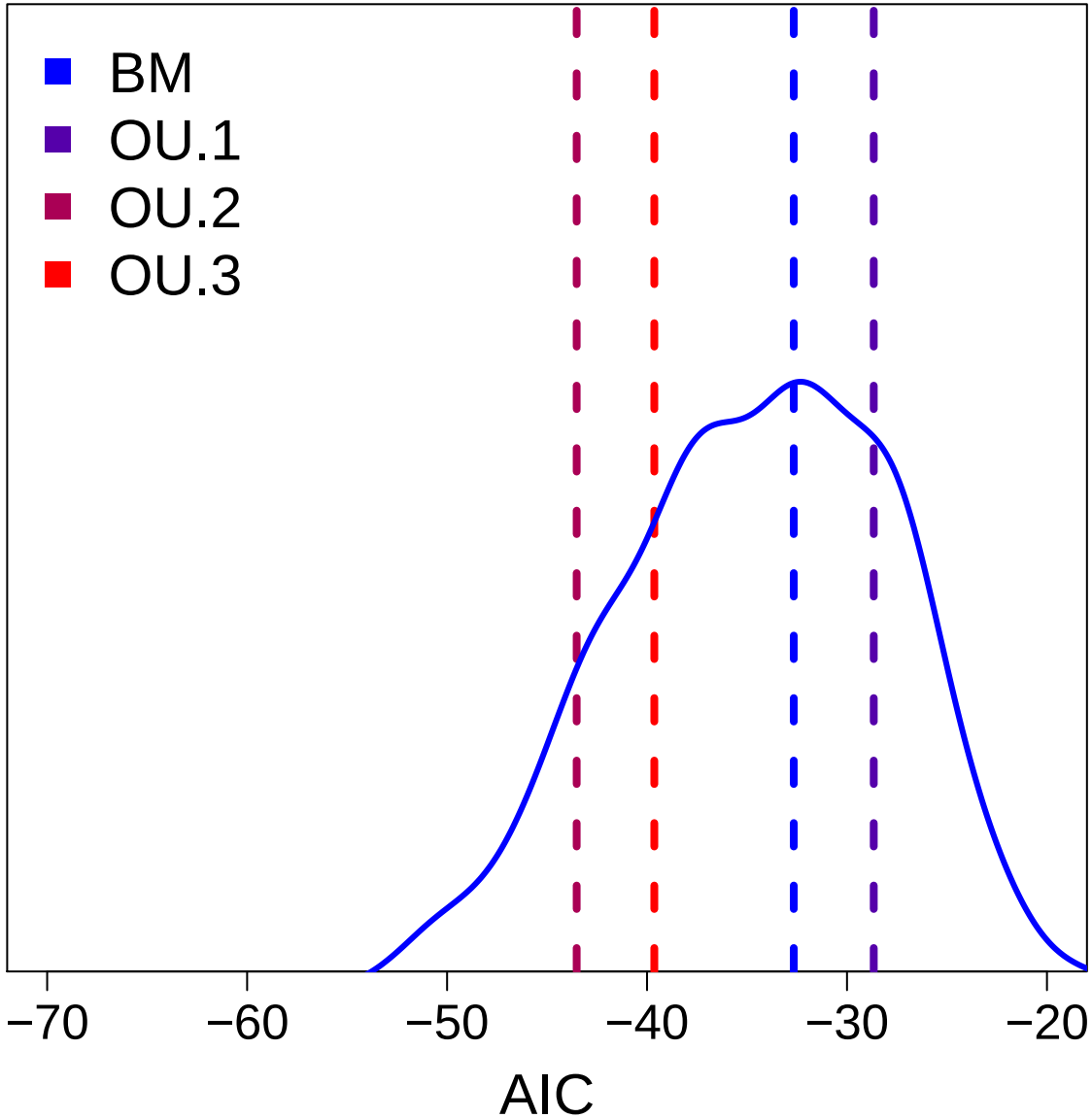
(Better Scores)

Comparing Models: AIC



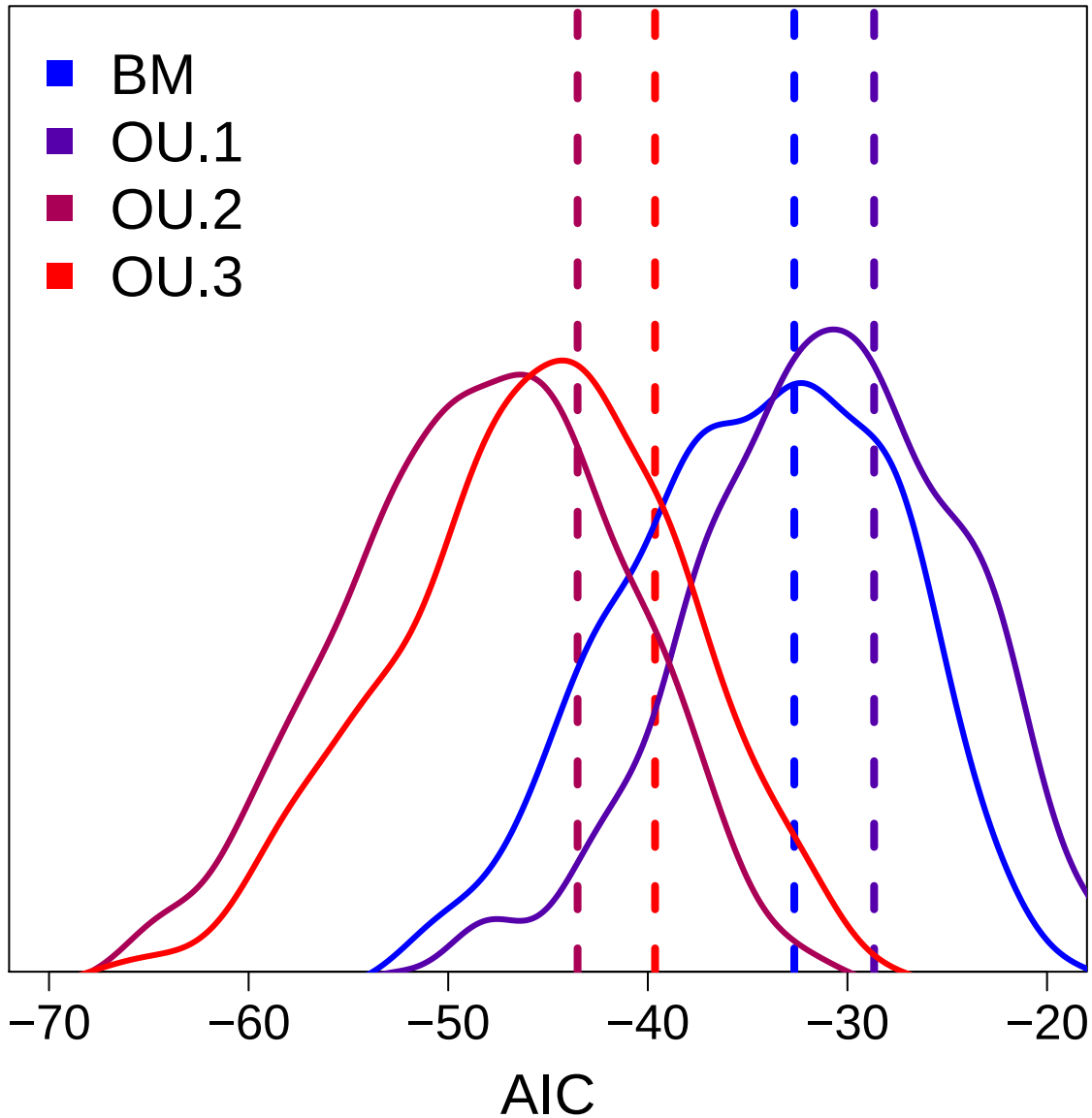
(Better Scores)

Comparing Models: Estimating Uncertainty



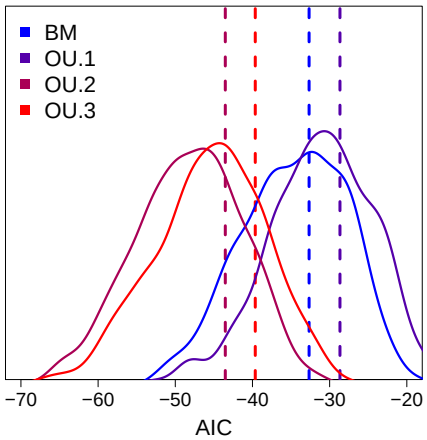
(Better Scores)

Comparing Models: Uncertainty dominates

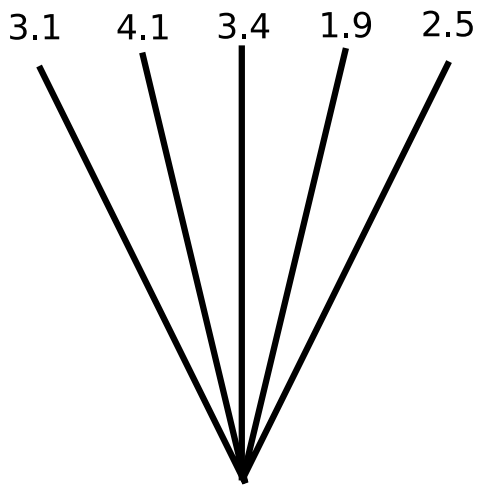


(Better Scores)

Sources of this uncertainty

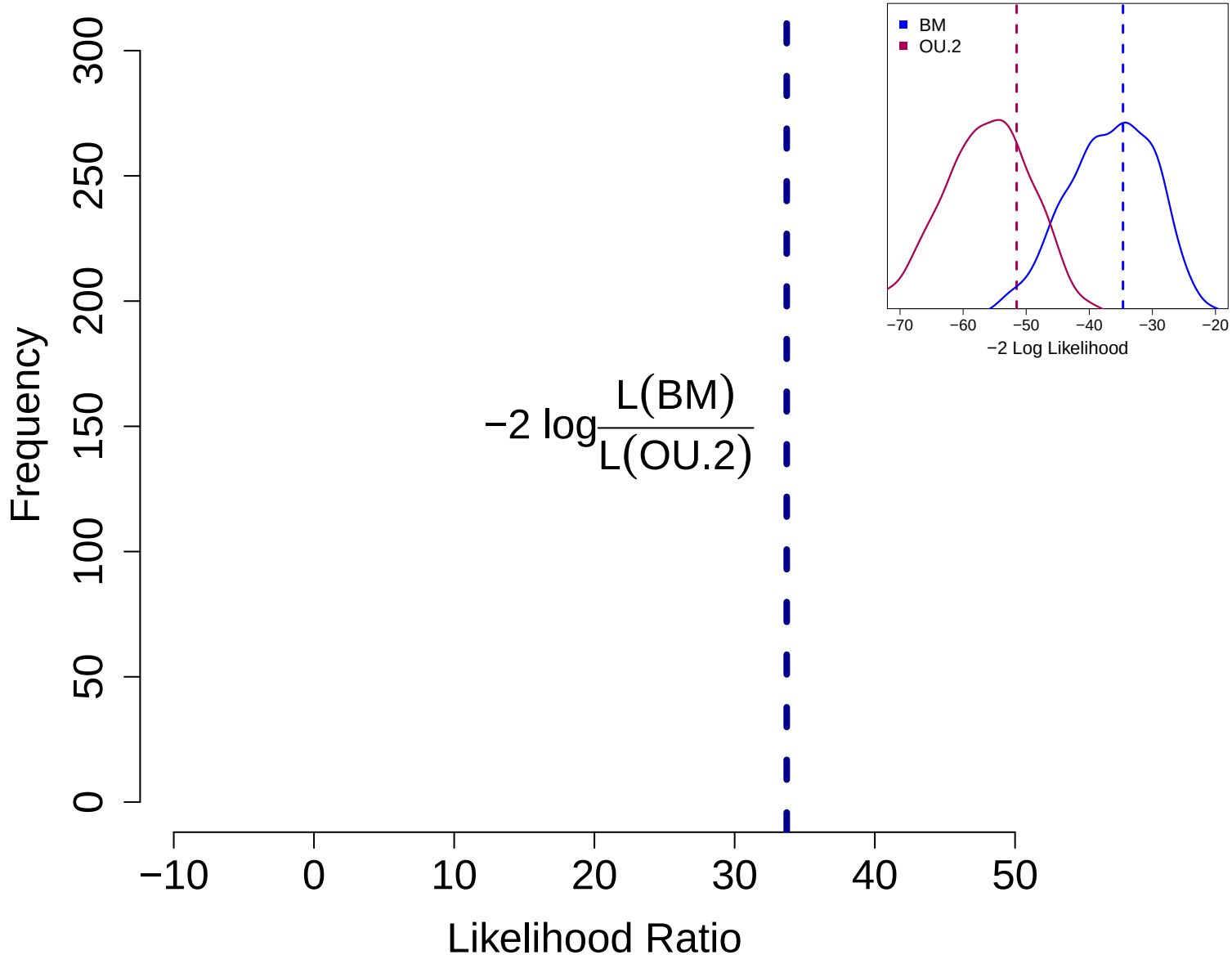


- Small datasets
- Uninformative topology
- Model details (*i.e.* high rates)

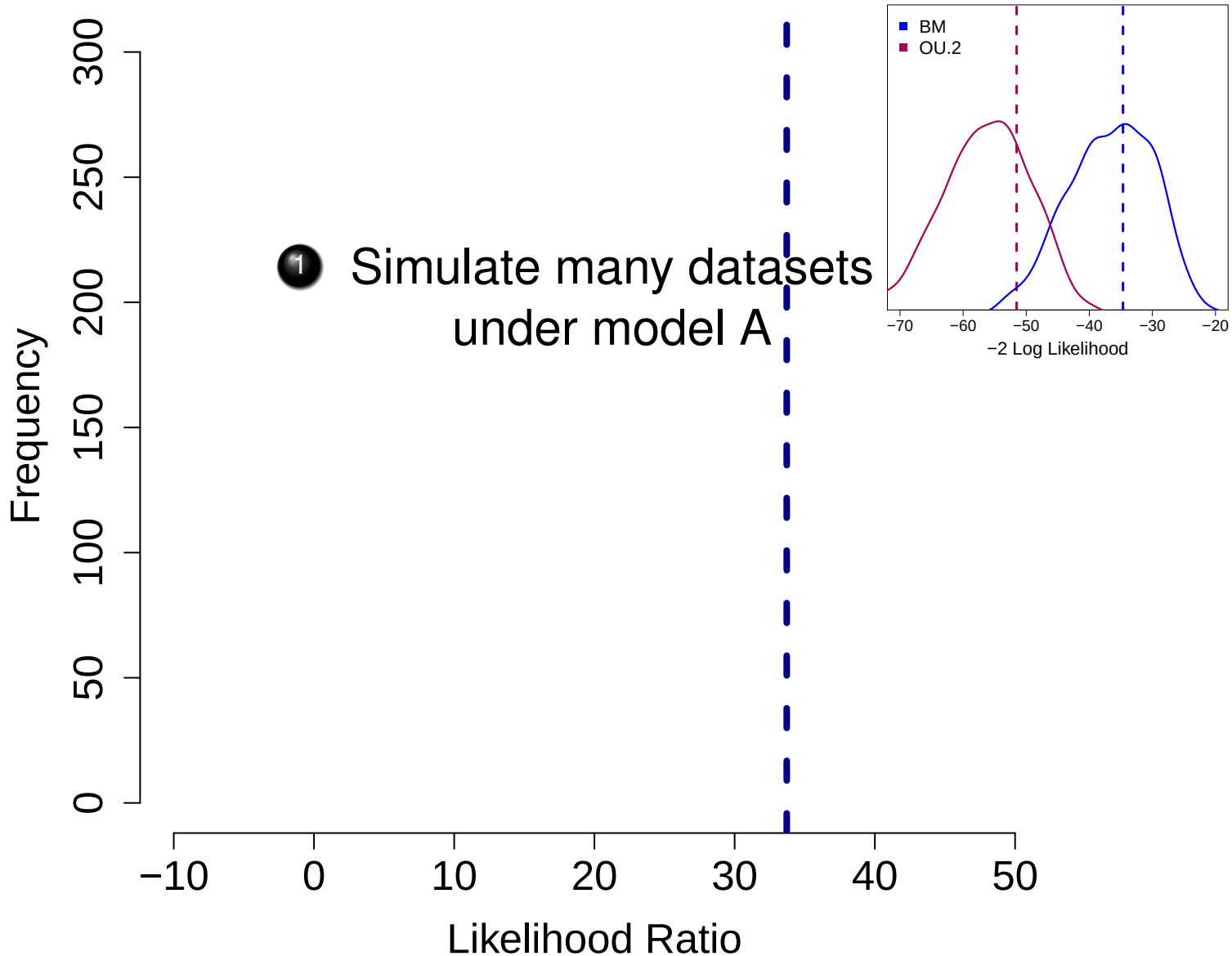


Information criteria alone may be misleading

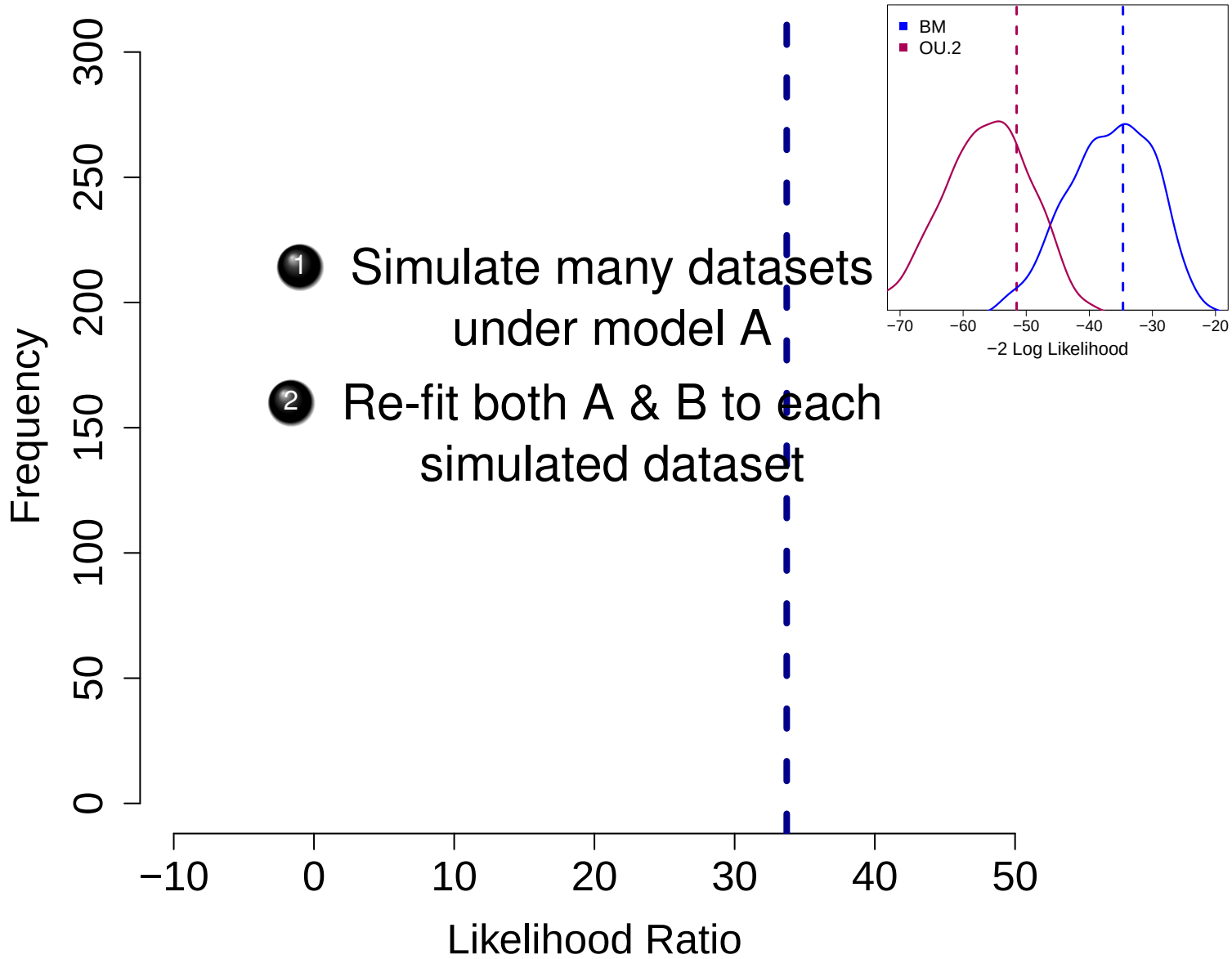
A Better Way: Comparing Models Directly



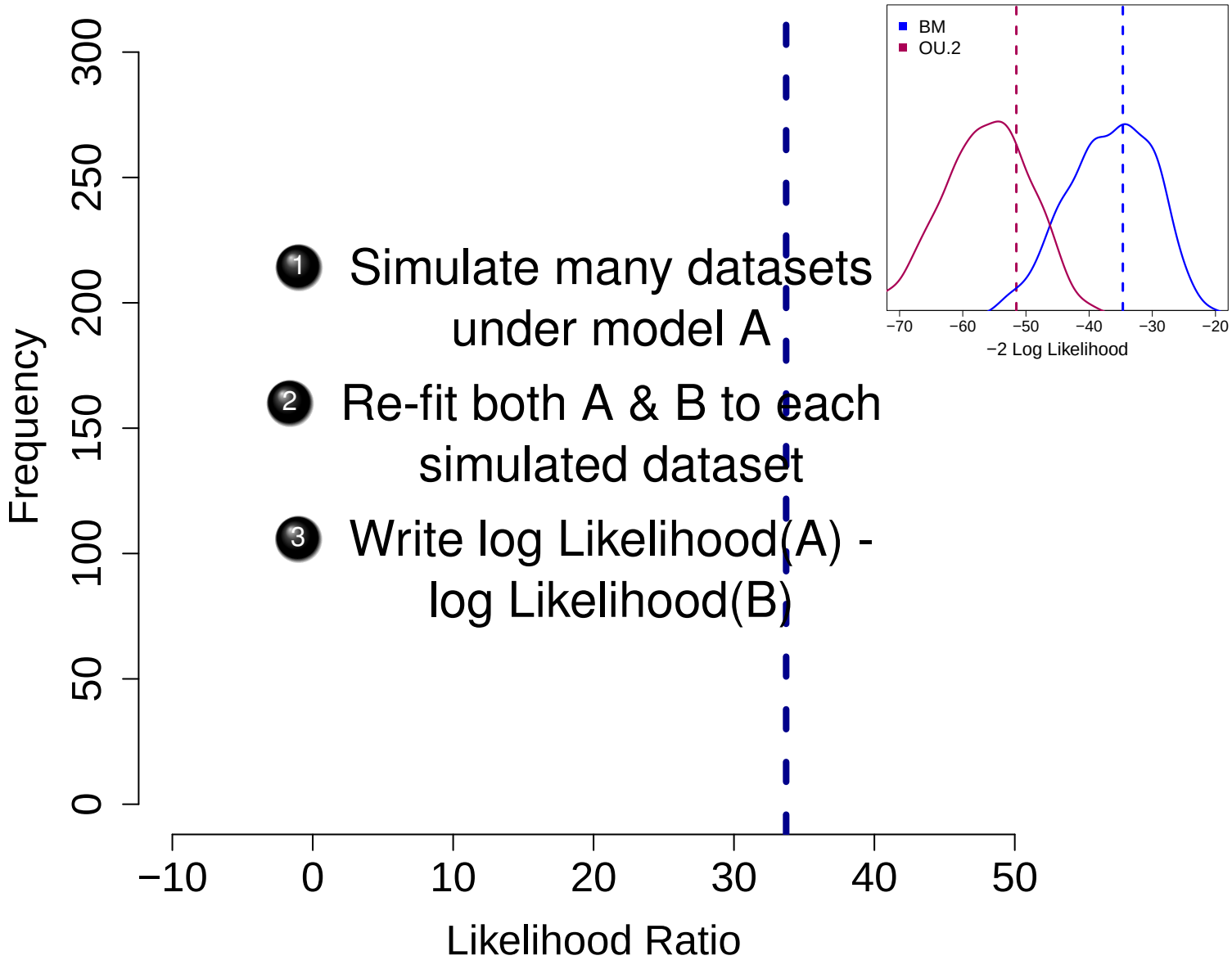
Method


1
Simulate many datasets
under model A
Frequency
0
50
100
150
200
250
300
−10
0
10
20
30
40
50
Likelihood Ratio
BM
OU.2
−70
−60
−50
−40
−30
−20
−2 Log Likelihood

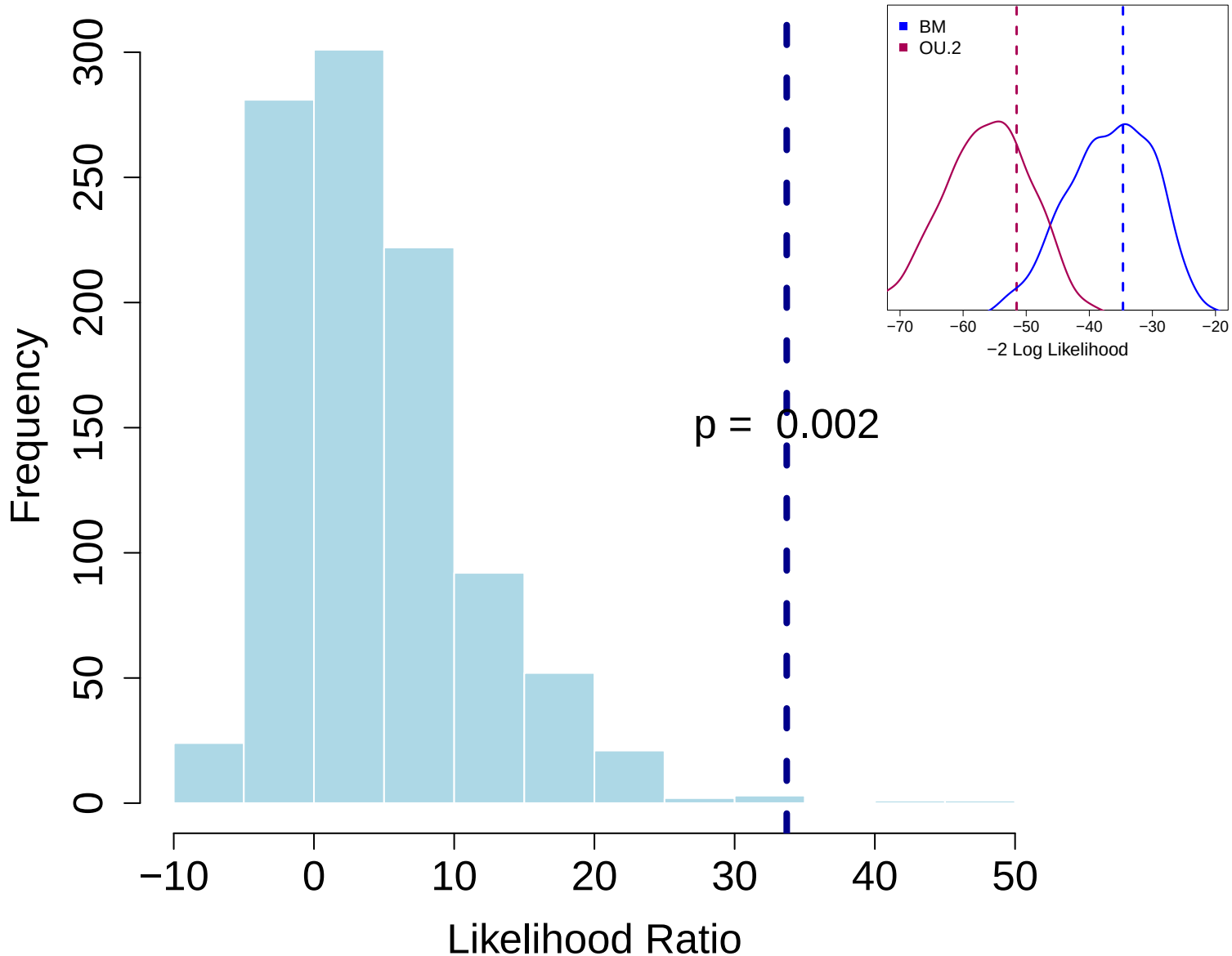
Method


Frequency
0
50
100
150
200
250
300
−10
0
10
20
30
40
50
Likelihood Ratio
1 Simulate many datasets under model A
2 Re-fit both A & B to each simulated dataset
BM
OU.2
−70
−60
−50
−40
−30
−20
−2 Log Likelihood

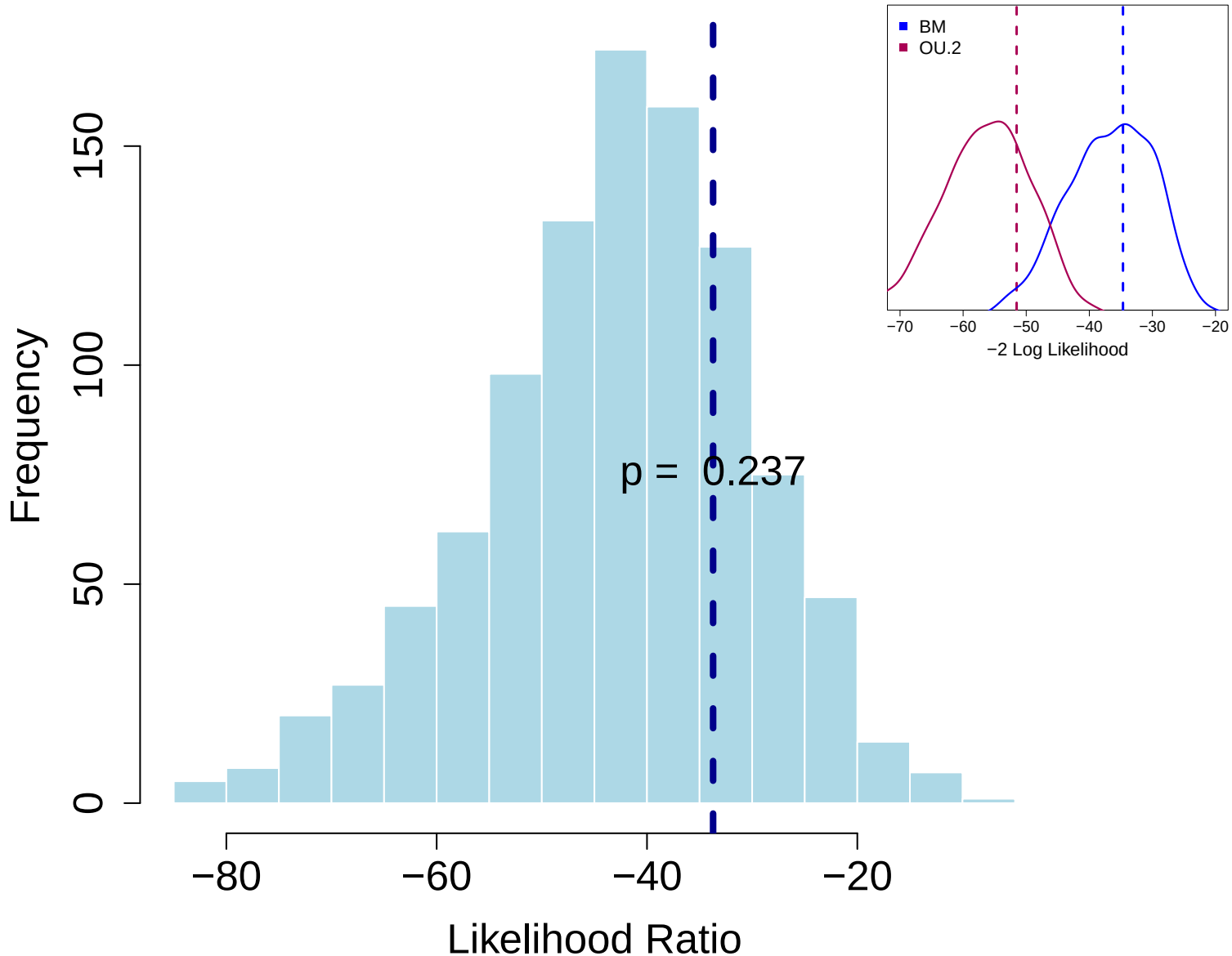
Method


Frequency
0
50
100
150
200
250
300
−10
0
10
20
30
40
50
Likelihood Ratio
1 Simulate many datasets under model A
2 Re-fit both A & B to each simulated dataset
3 Write log Likelihood(A) - log Likelihood(B)
BM
OU.2
−70
−60
−50
−40
−30
−20
−2 Log Likelihood

BM vs OU.2

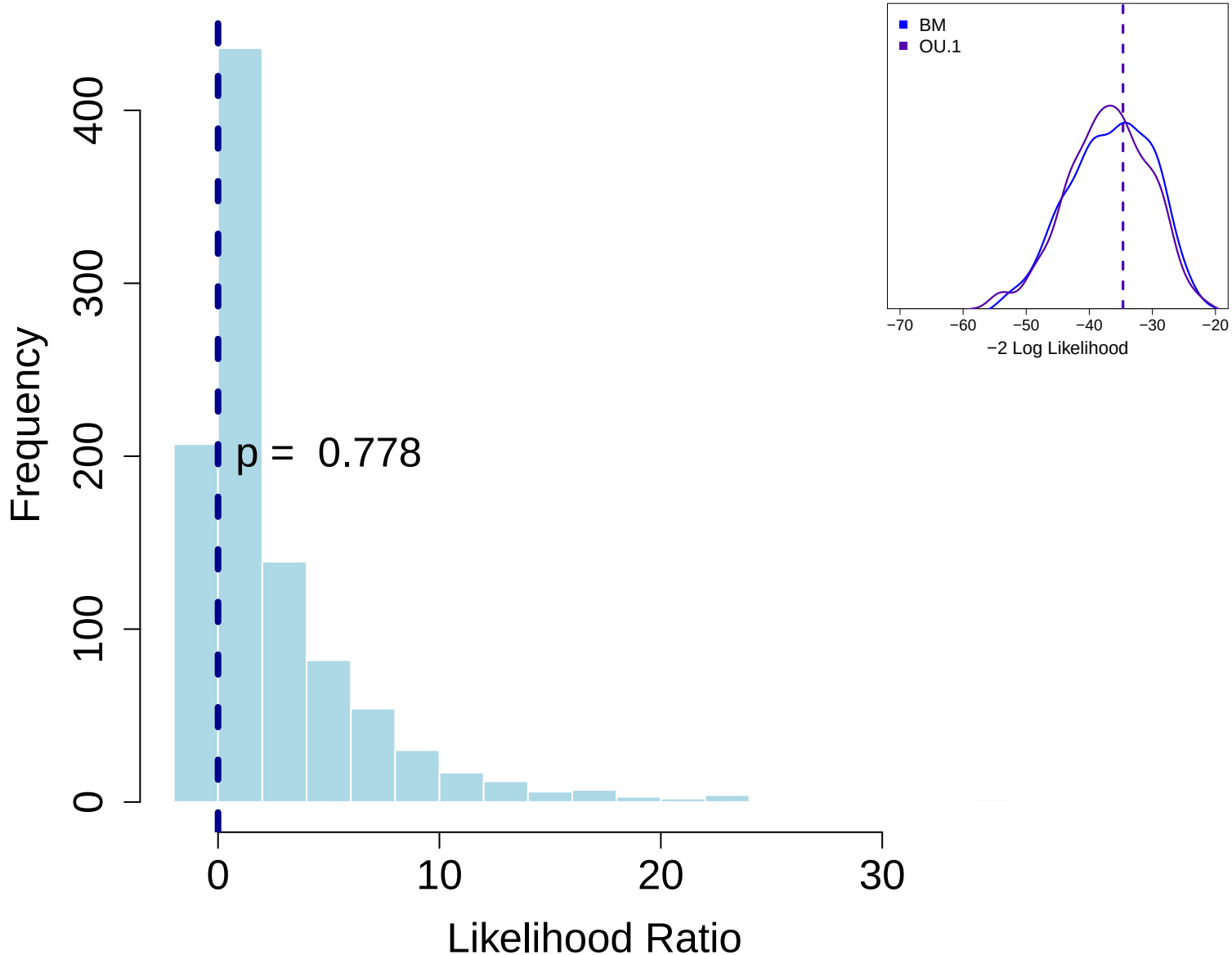

Frequency
0
50
100
150
200
250
300
−10
0
10
20
30
40
50
Likelihood Ratio
p = 0.002
BM
OU.2
−70
−60
−50
−40
−30
−20
−2 Log Likelihood

OU.2 vs BM: Simulating under OU.2

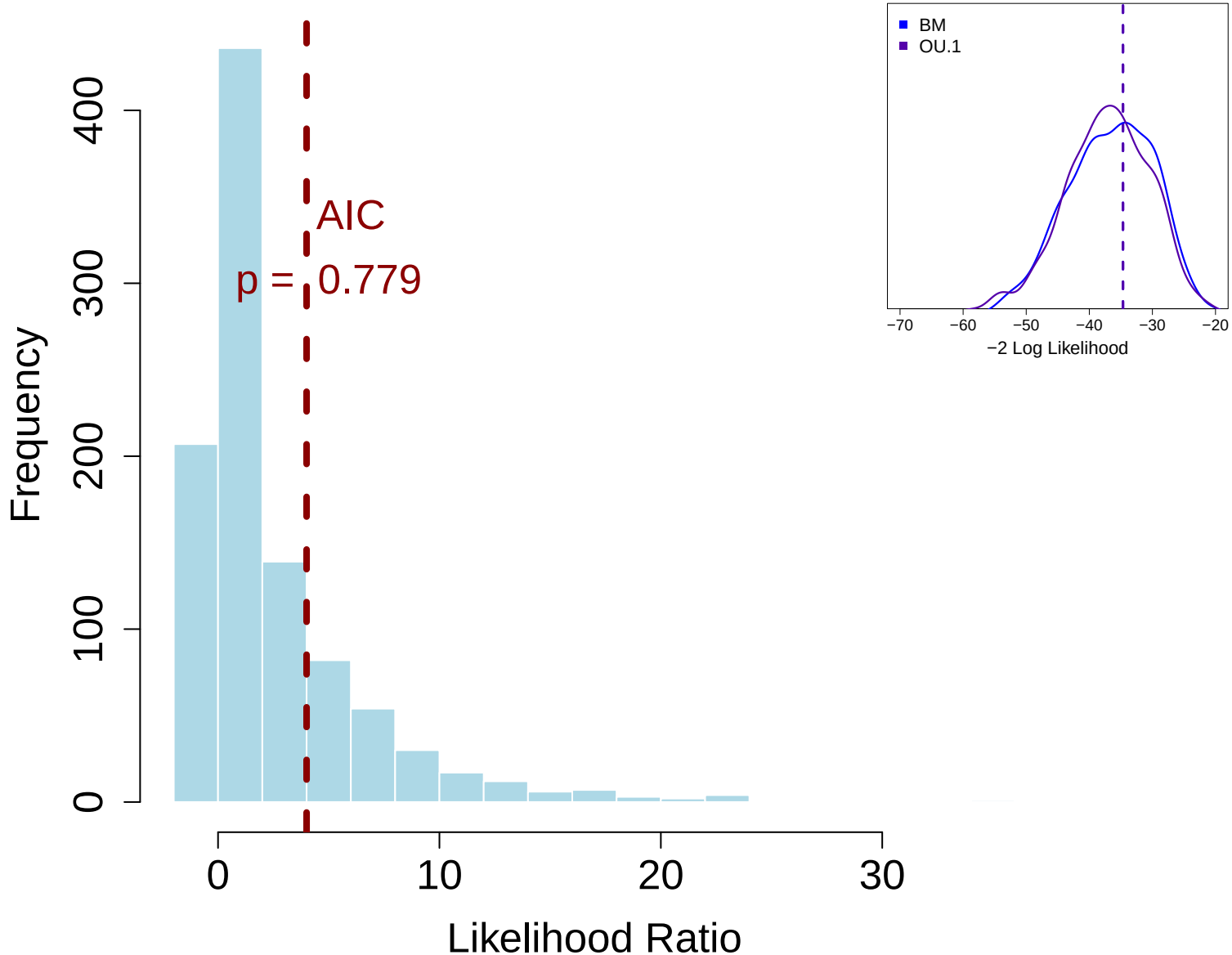


Model A rejects Model B.
Model B doesn't reject Model A.

How about two very similar models? BM vs OU.1

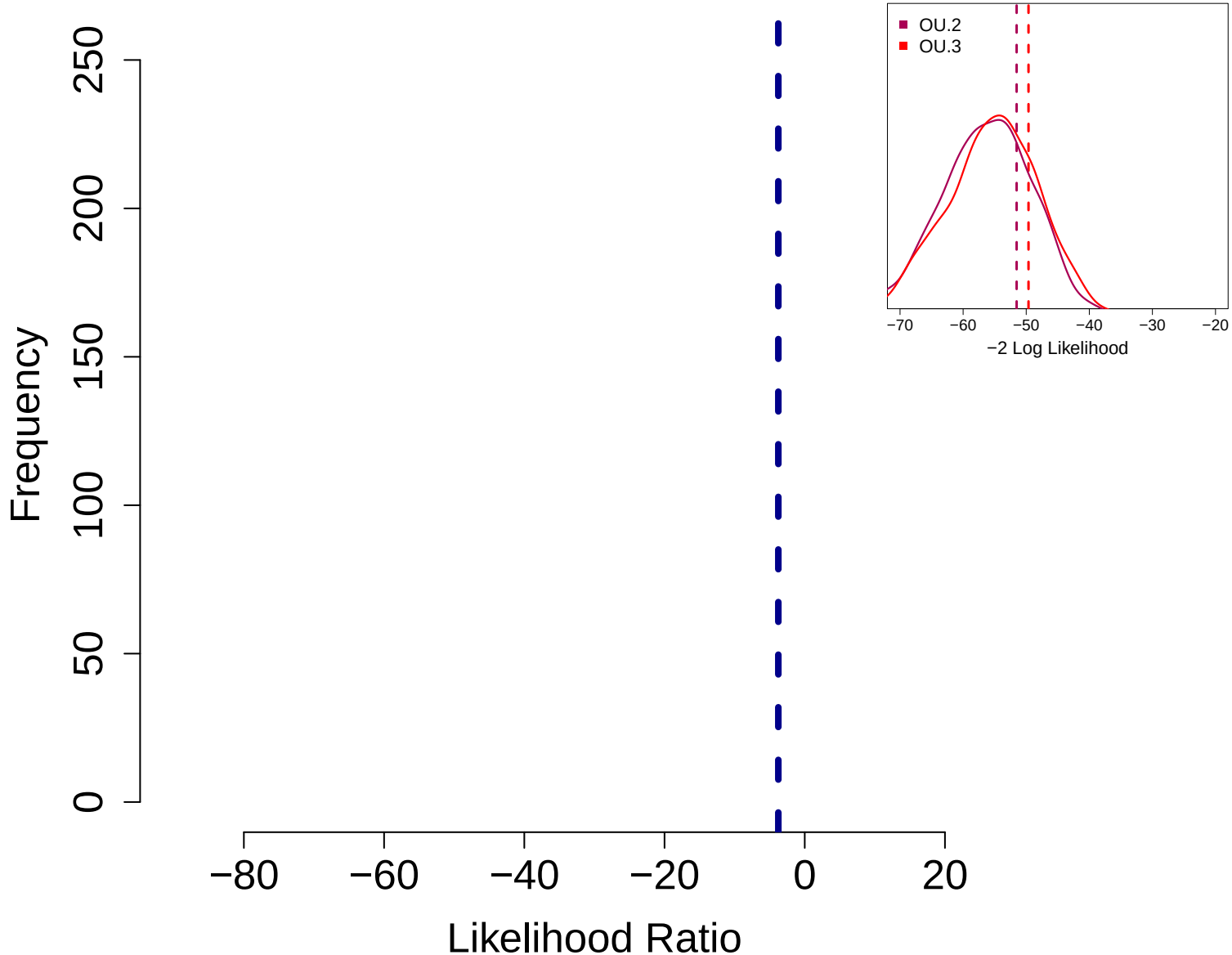


How would AIC rule compare?

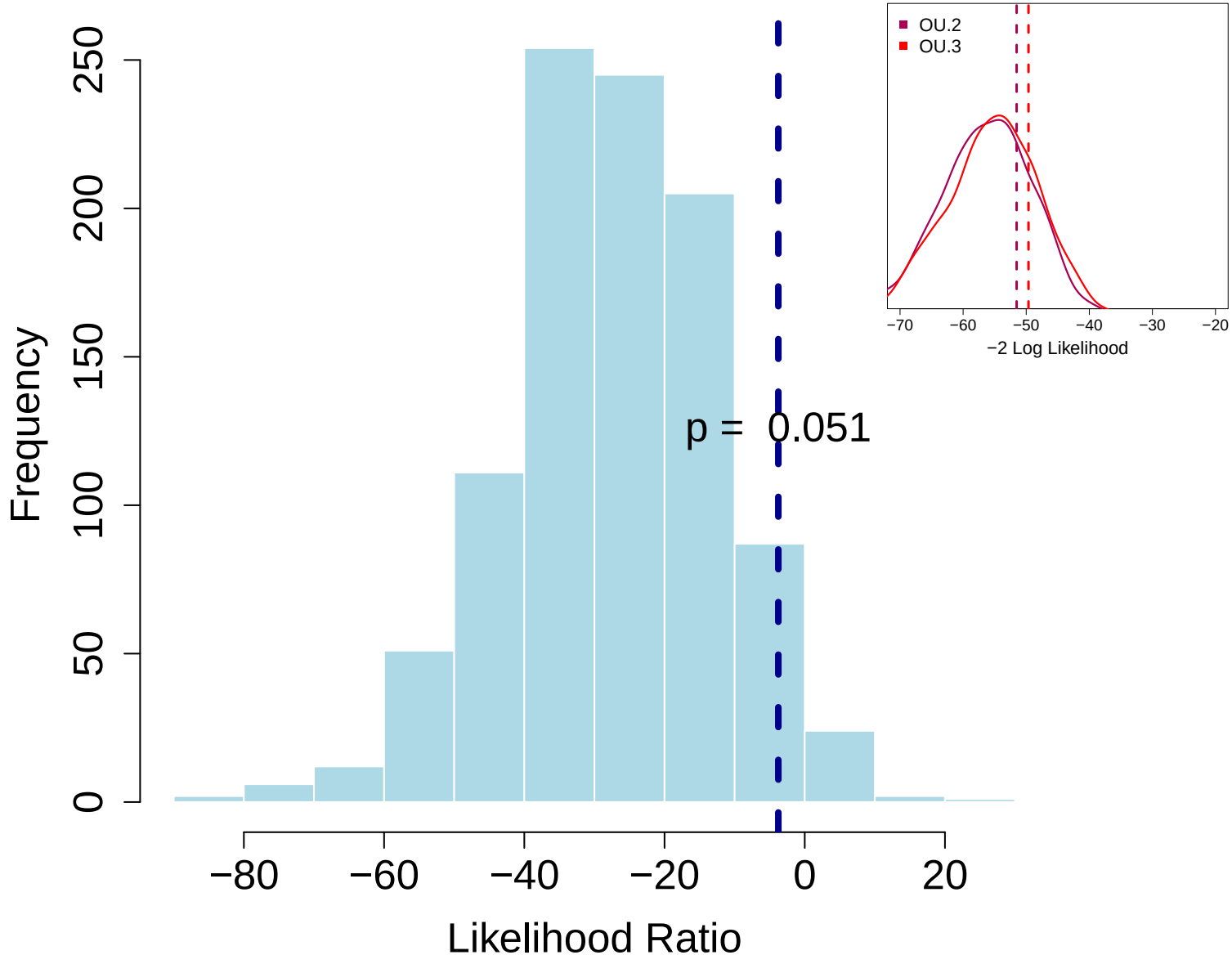


When data is insufficient to distinguish, method can say *“I don’t know”*

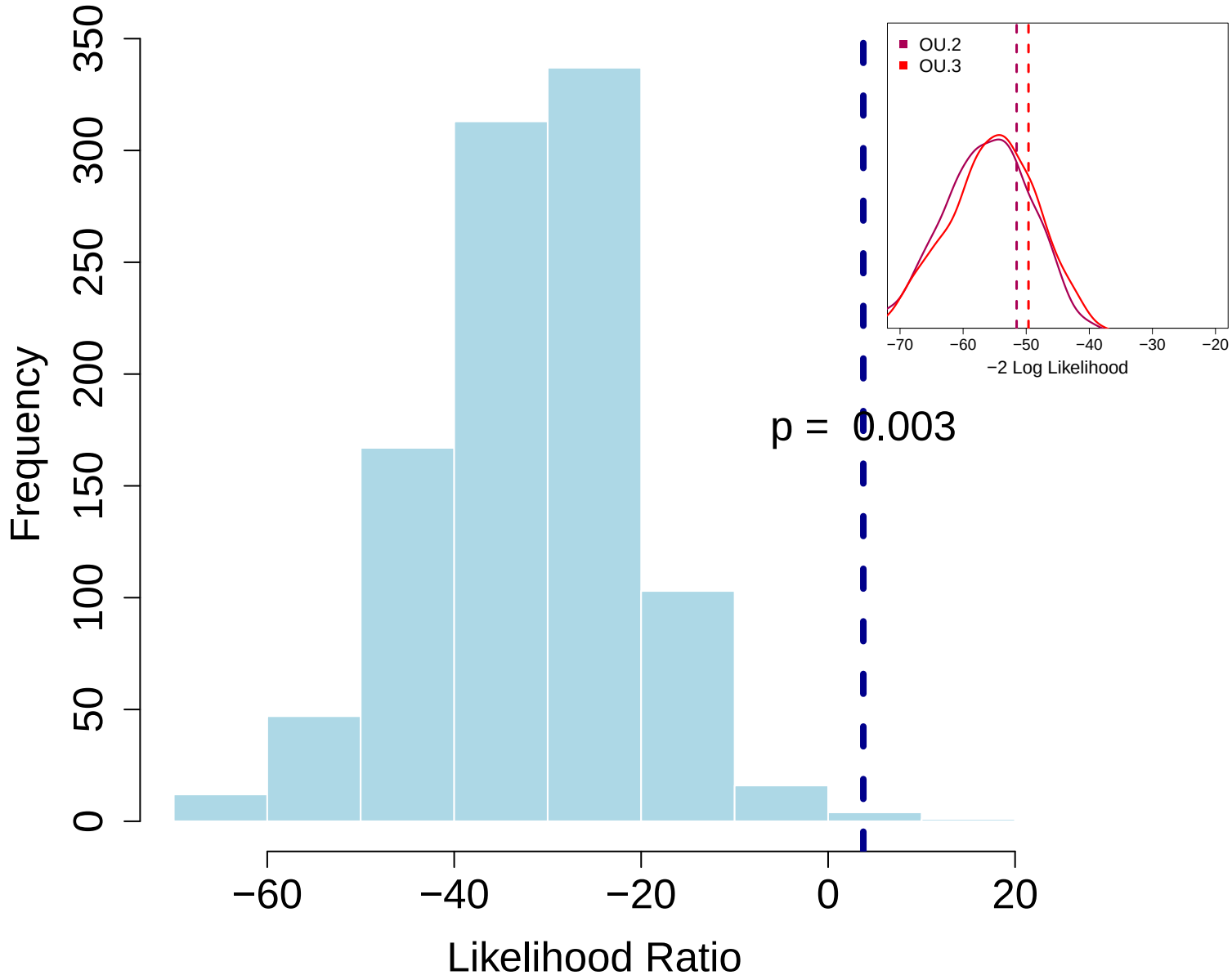
Can we distinguish between OU.2 and OU.3?



Simulate under OU.2 and compare to OU.3 . . .

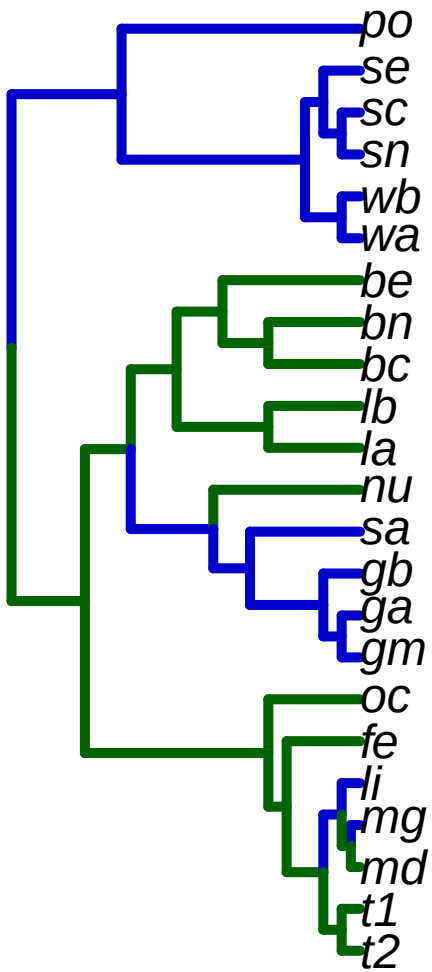


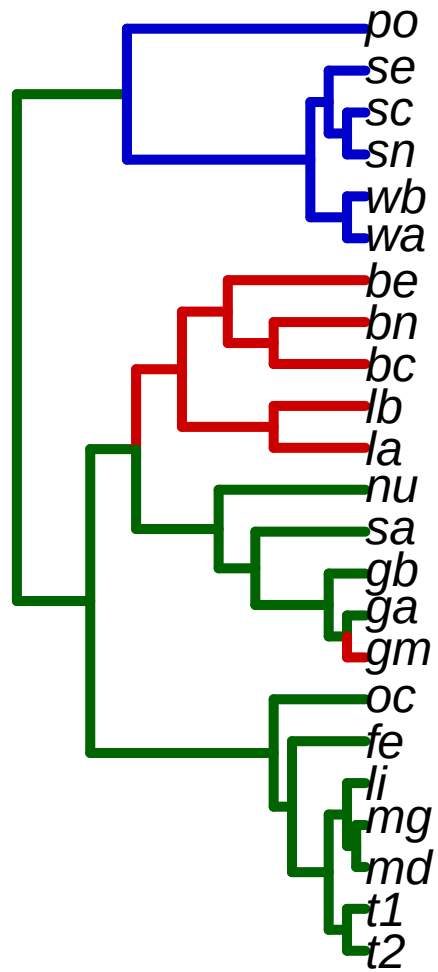
OU.3 vs OU.2: Now we're preferring OU.2!



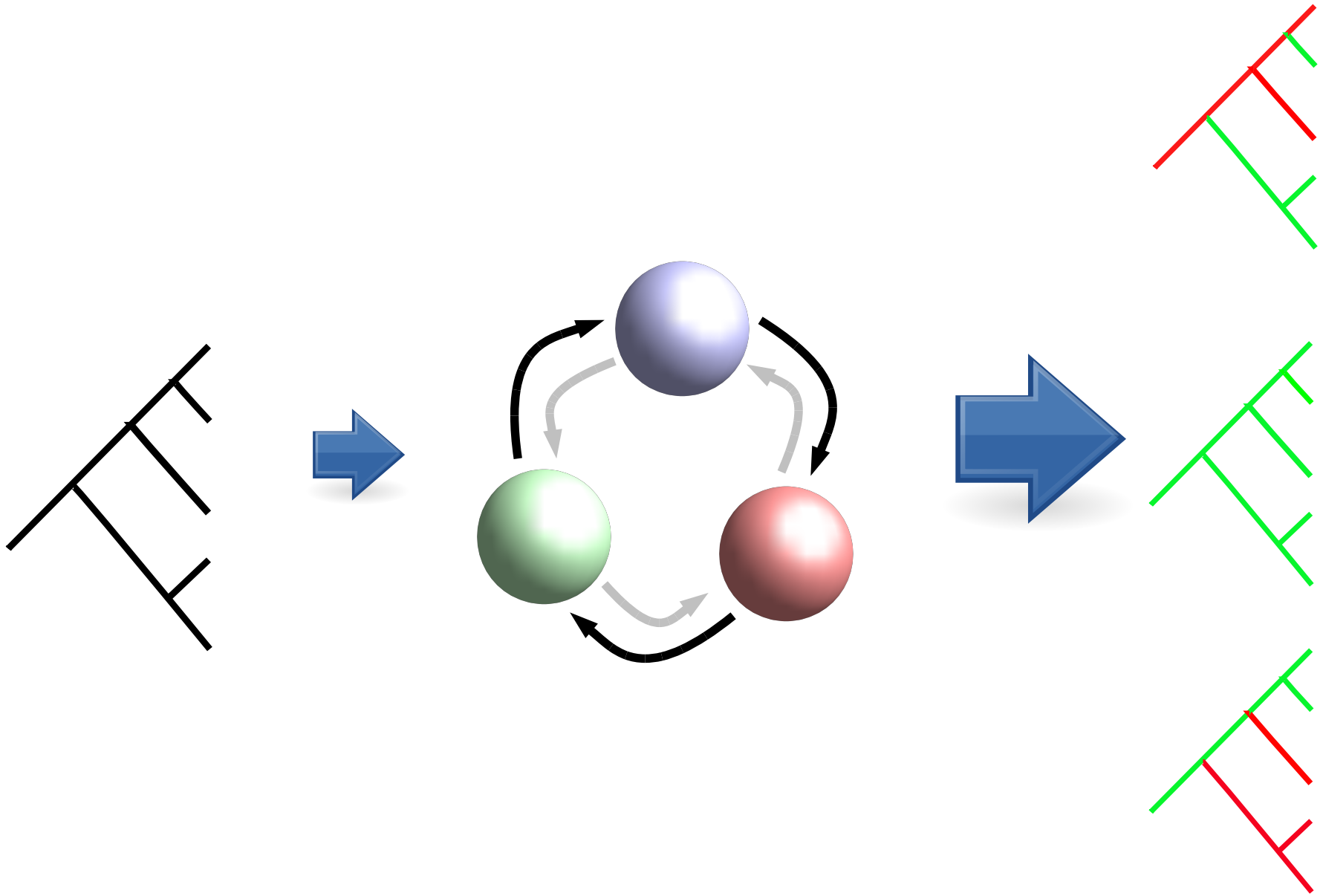
Model A rejects Model B.
Model B rejects Model A.

Non-nested models



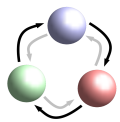


Replacing paintings with a transition model



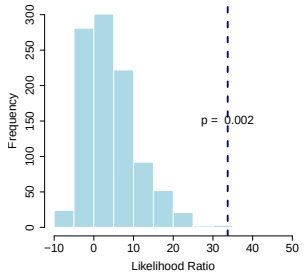
- All models are nested
- Estimate *number* of niches
- Also estimate *rates* of transitions

A hard problem in two easy pieces

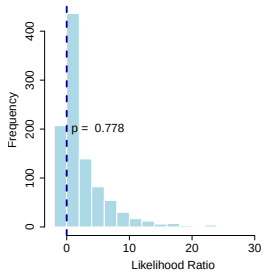
$$P(\text{  } \mid \text{  }) =$$
$$P(\text{  } \mid \text{  })P(\text{} \mid \text{})$$

Summary

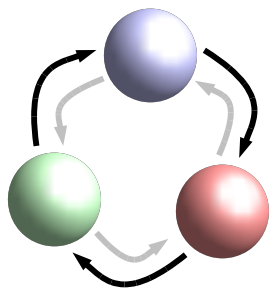
1. Quantifiable, robust model choice



2. Identify when data is insufficient

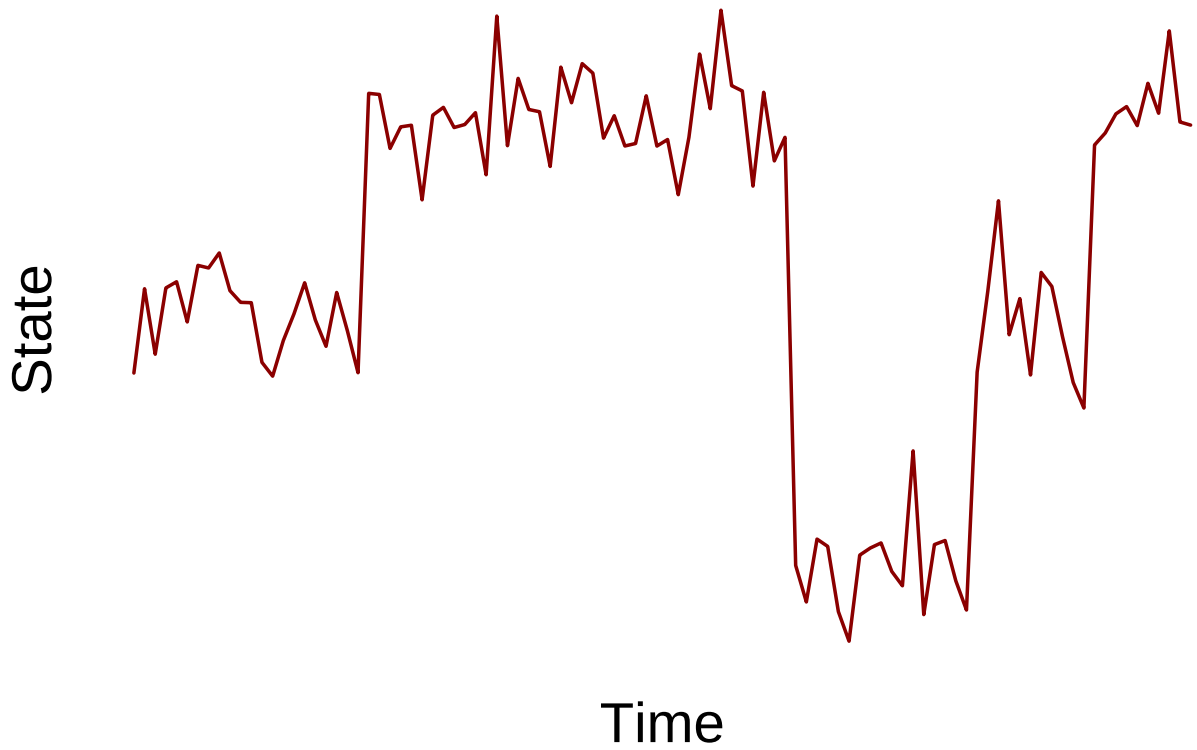


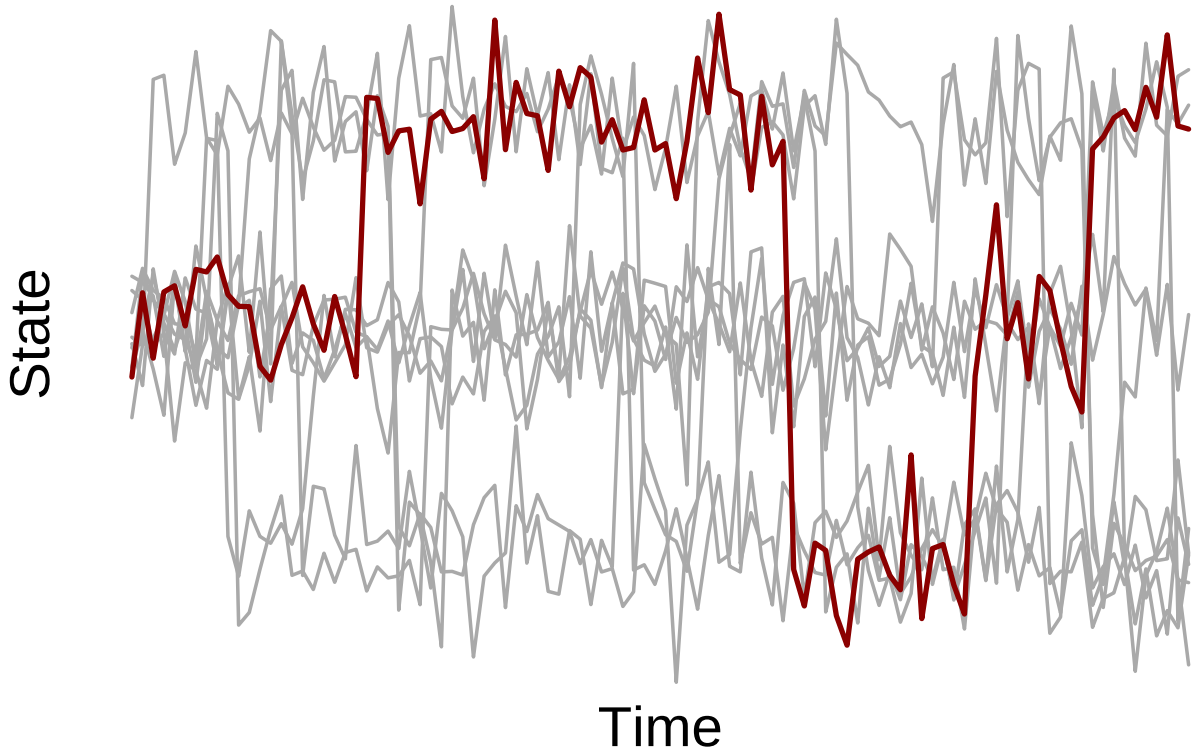
3. New framework avoids painting & non-nested comparison

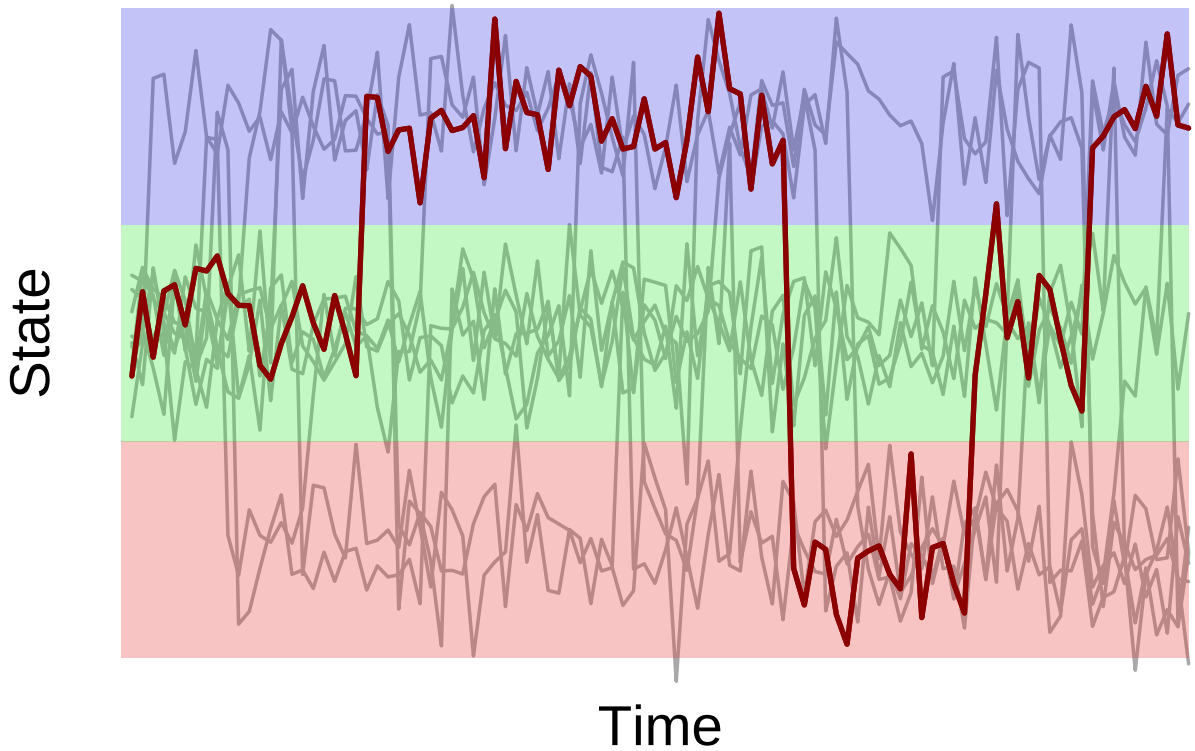


Thanks!

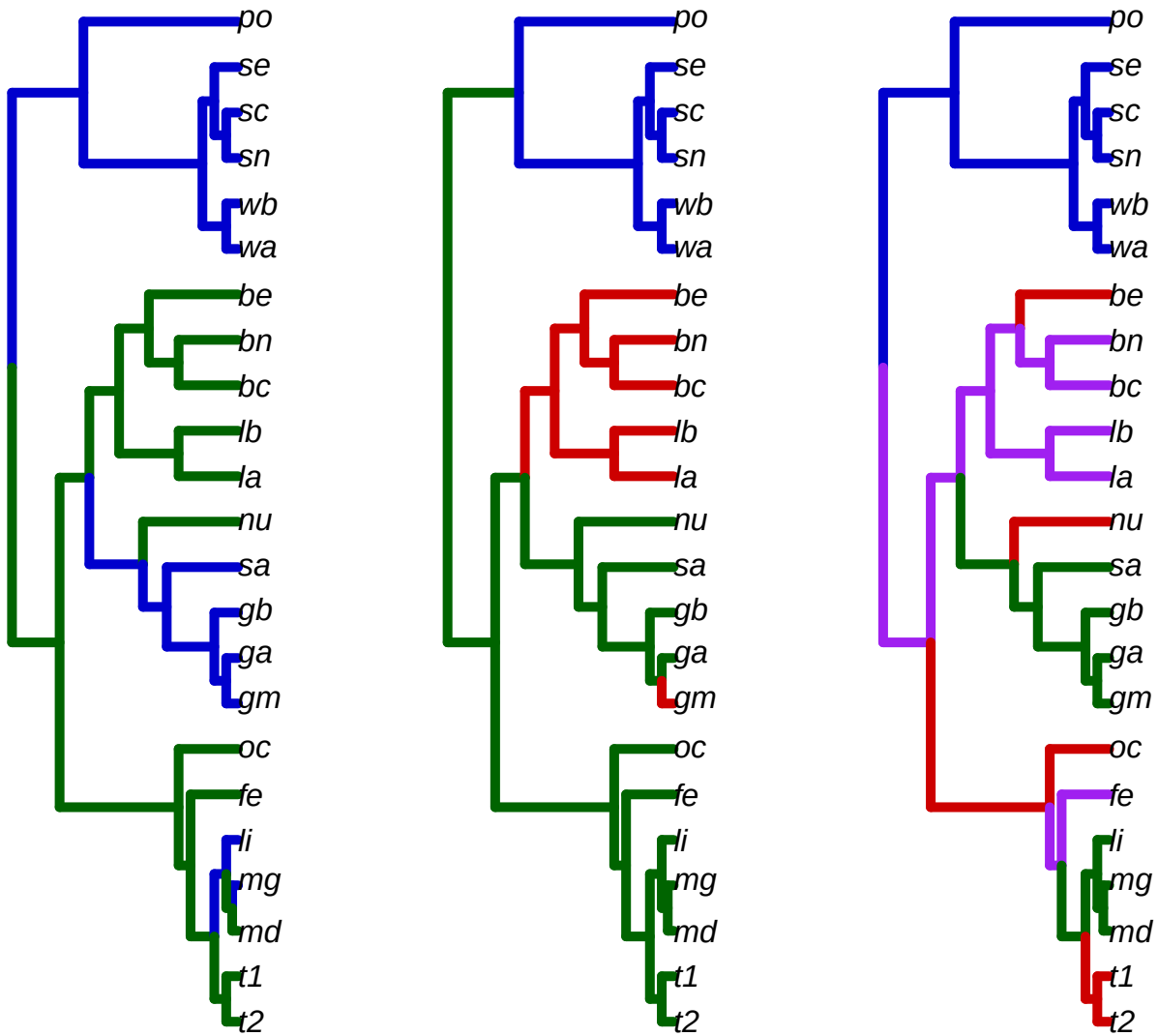
- Chris Martin
- Peter Wainwright
- Samantha Price
- Roi Holzman
- Graham Coop
- Peter Ralph
- Alan Hastings
- DoE CSGF


State
Time


State
Time


State
Time

Comparing Models



OU.3 vs OU.4: Why you should mistrust painting trees