PENNSTATE
Center for
Exoplanets and
Habitable Worlds

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SimpleABC

Approximate Bayesian
Computation for Python

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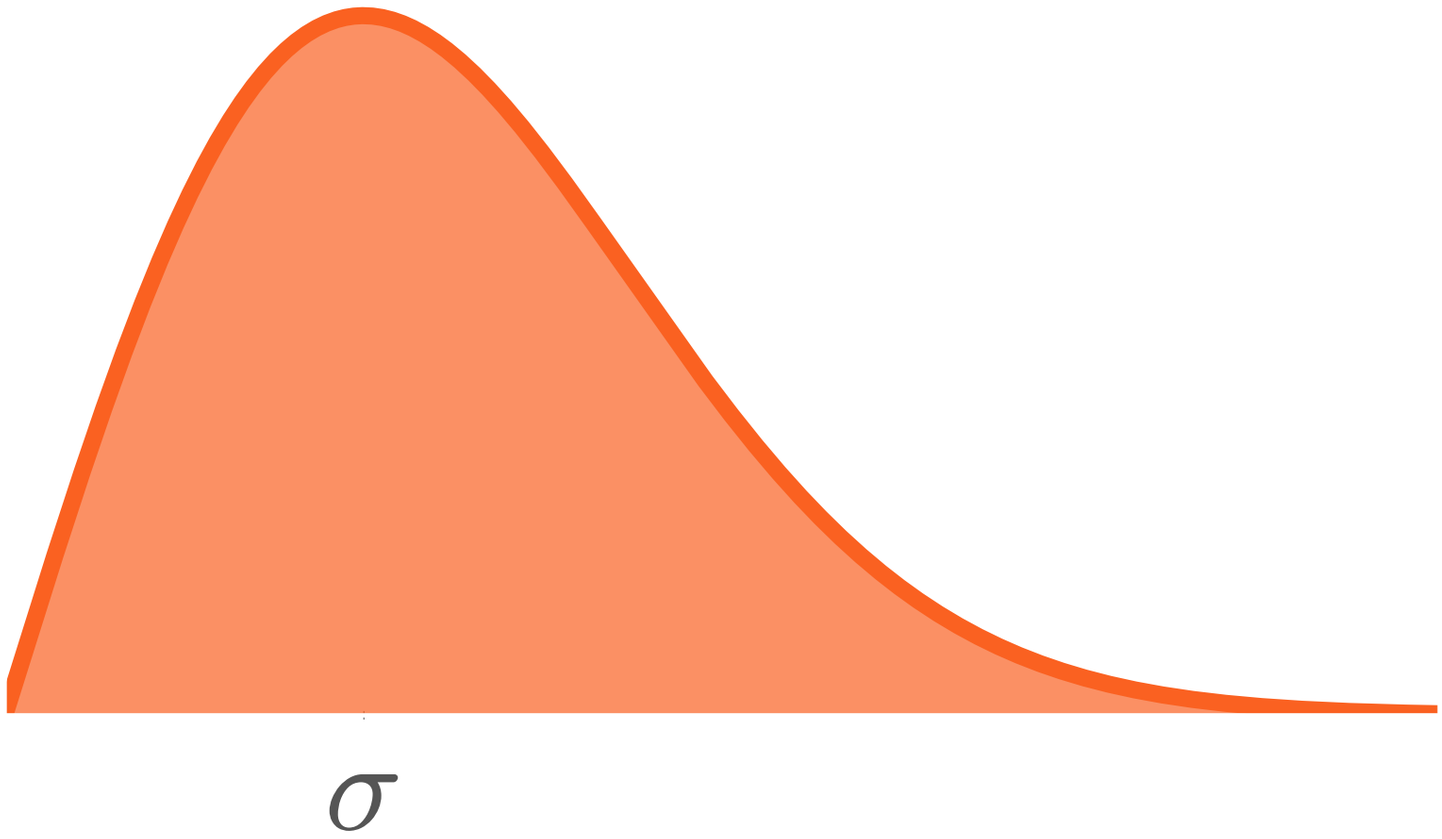
Approximate Bayesian Computation

- ABC is a likelihood-free method of Bayesian inference that uses simulation to approximate the true posterior distribution of a parameter. It may be appropriate to use in situations where:
  - The likelihood function is unknown or is too computationally expensive to compute.
  - There exists a good forward model that can produce data sets like the one of interest.

So how do you use ABC?

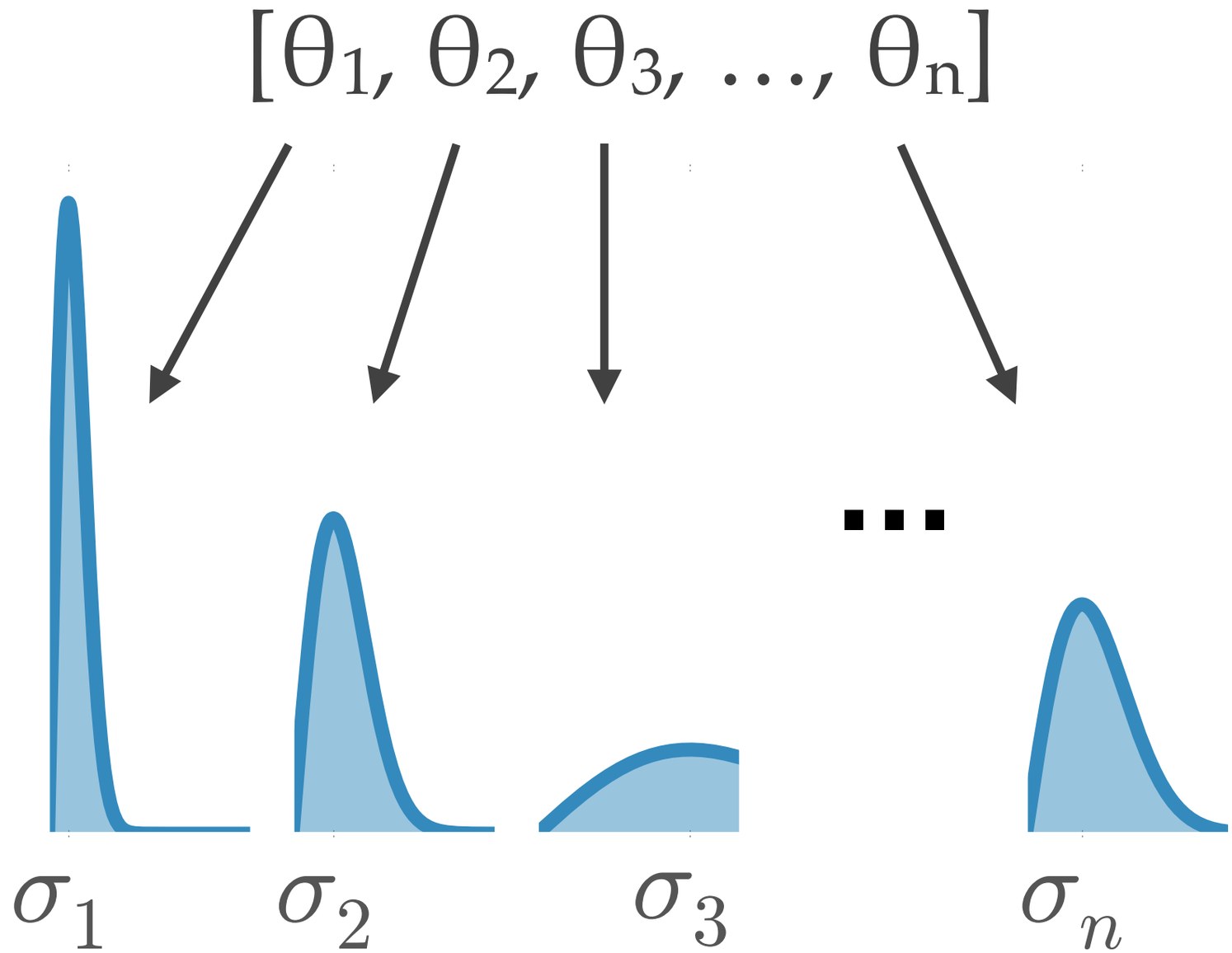
Step 1: Compute a summary statistic for your data.



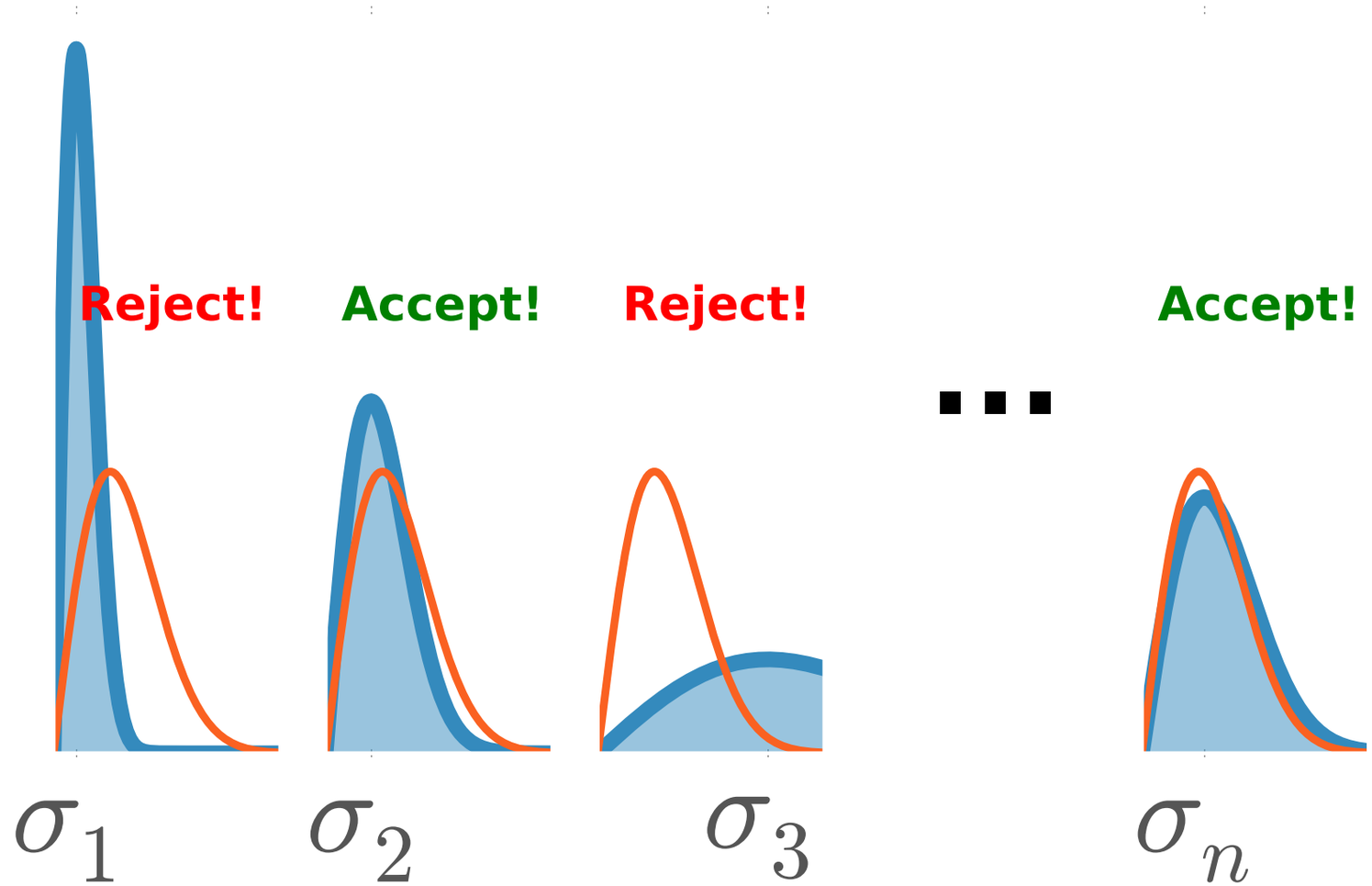
Step 2: Draw model parameters from your prior.

$[\theta_1, \theta_2, \theta_3, \ldots, \theta_n]$

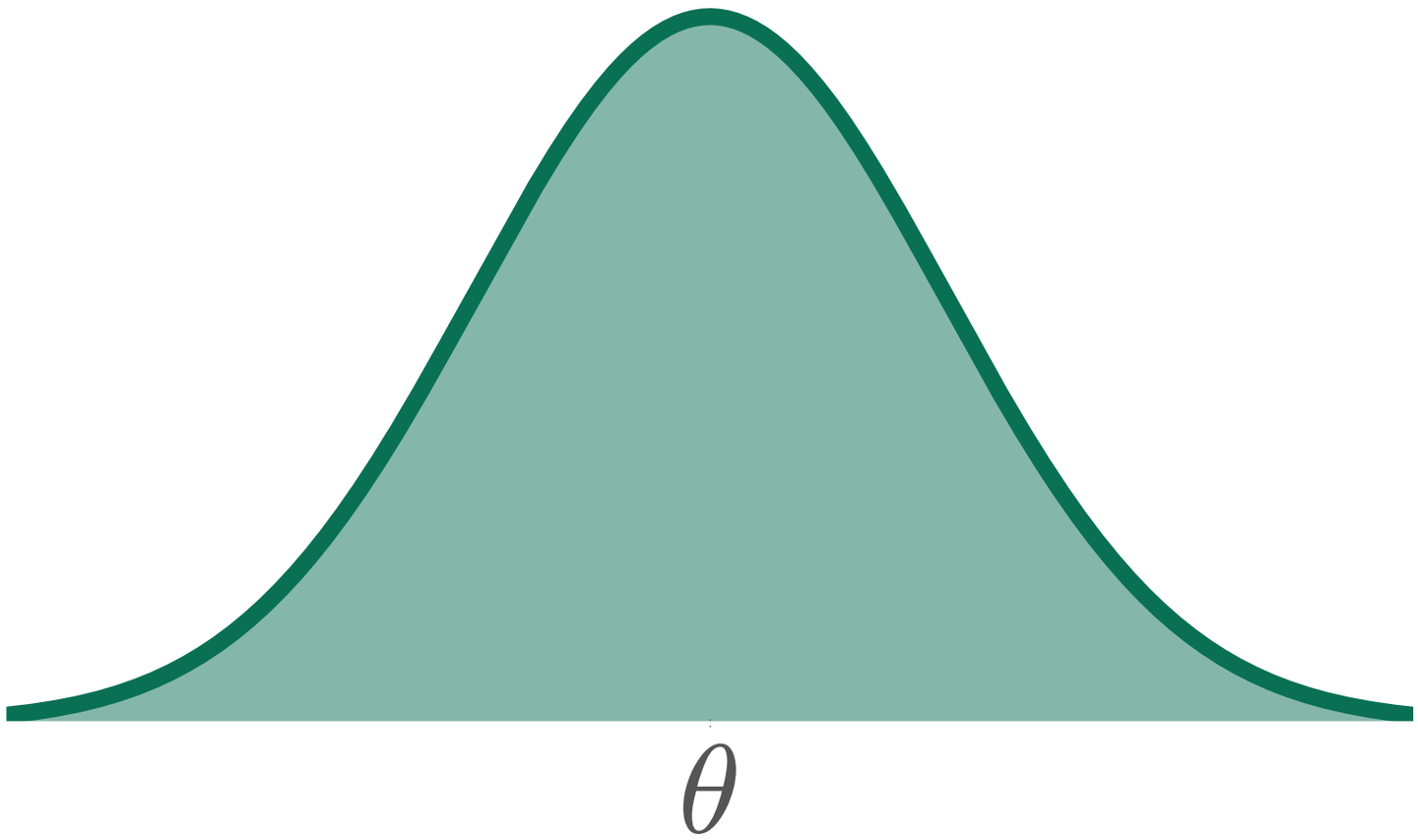
Step 3: Simulate data from the θ draws.



Step 4: Reject draws whose summary stat are further then the tolerance (ε) after applying a distance function.

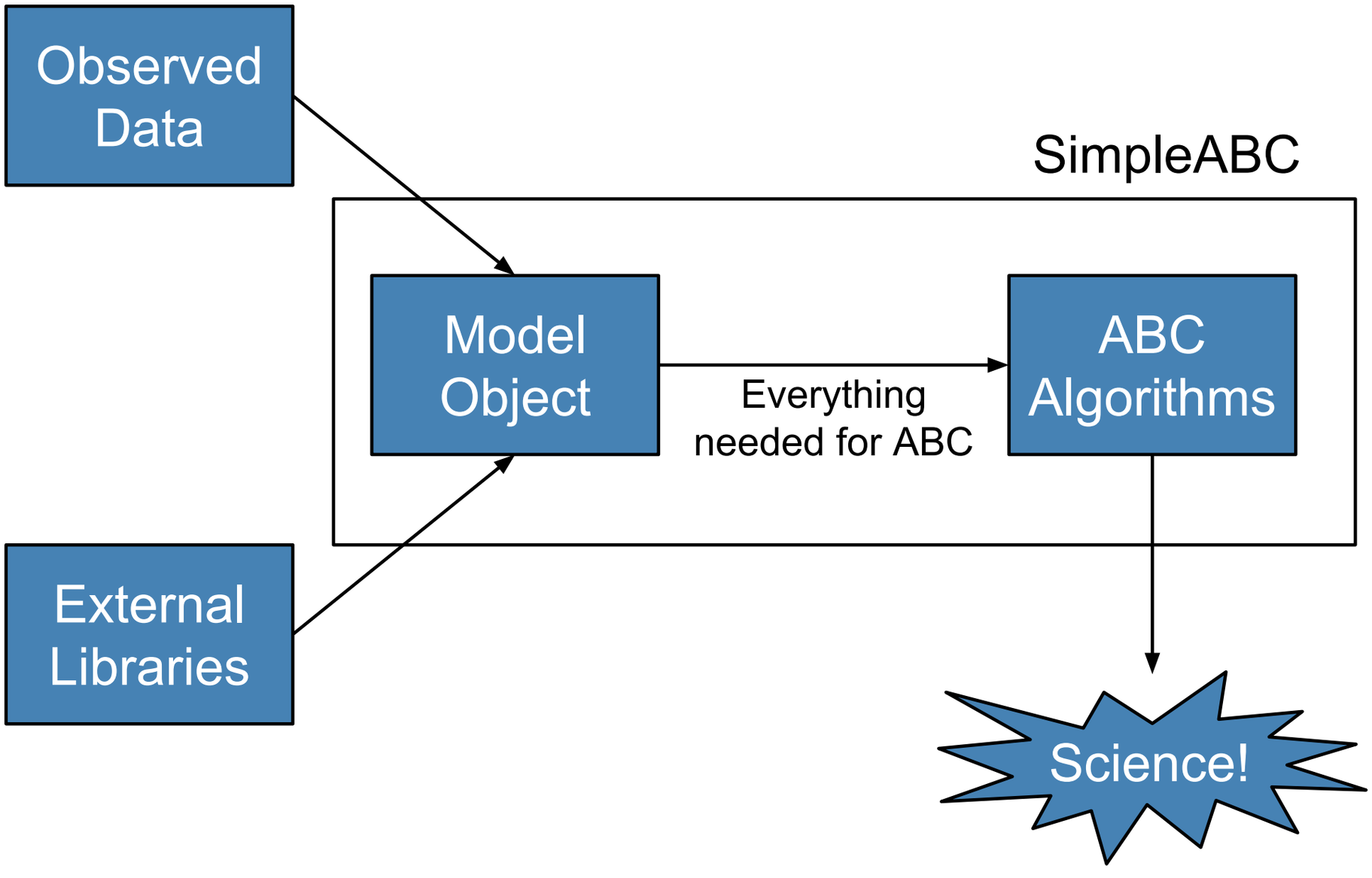


Step 5: The remaining θ draws are an approximation of the posterior distribution of the model parameters.



SimpleABC

SimpleABC uses a user supplied model object to interface with a library of ABC algorithm(s).



To create your model, you just sub class the model object.

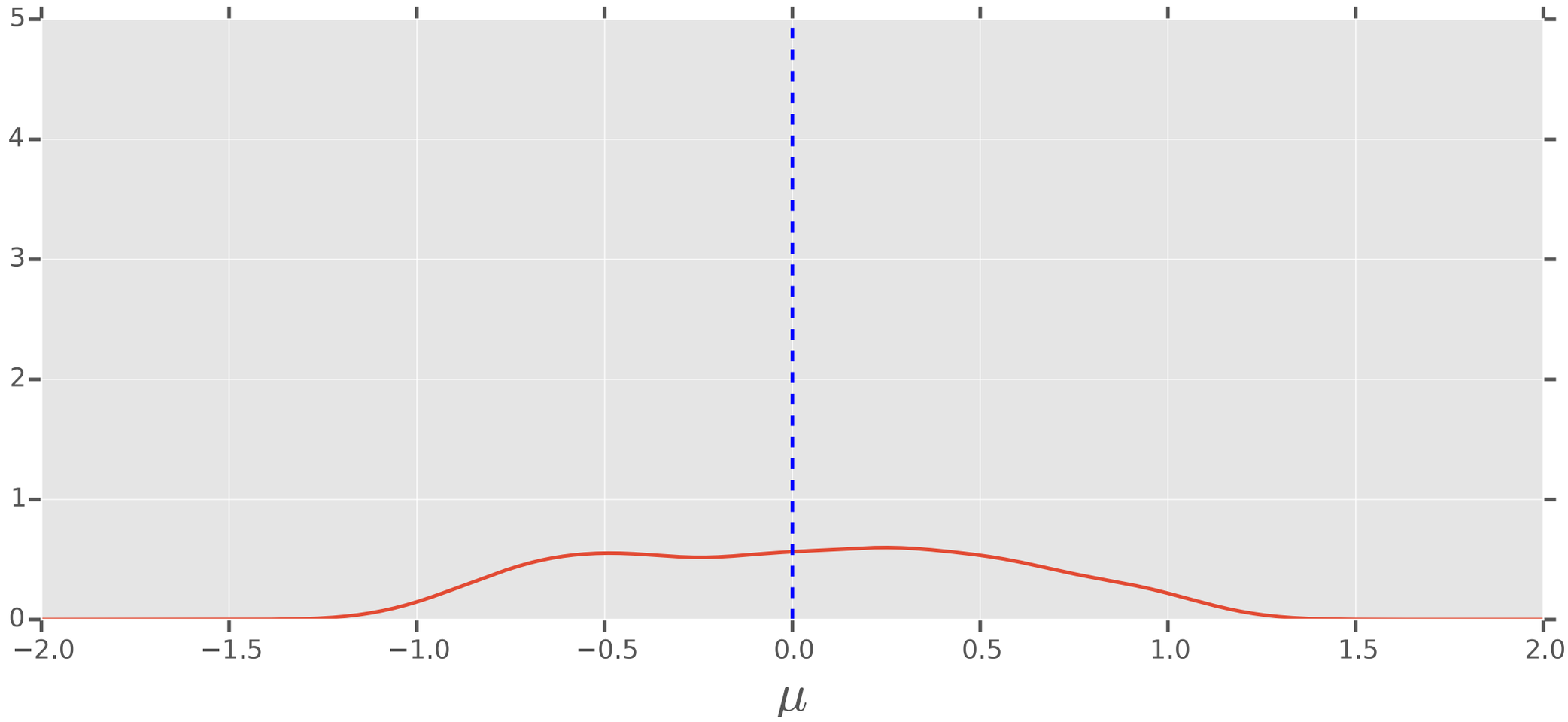
```
class Model(object):
    @abstractmethod
    def draw_theta(self):

    @abstractmethod
    def generate_data(self, theta):

    @abstractmethod
    def summary_stats(self, data):

    @abstractmethod
    def distance_function(self, summary_stats, summary_stats_synth):
```

Let’s try it with a Gaussian distribution.

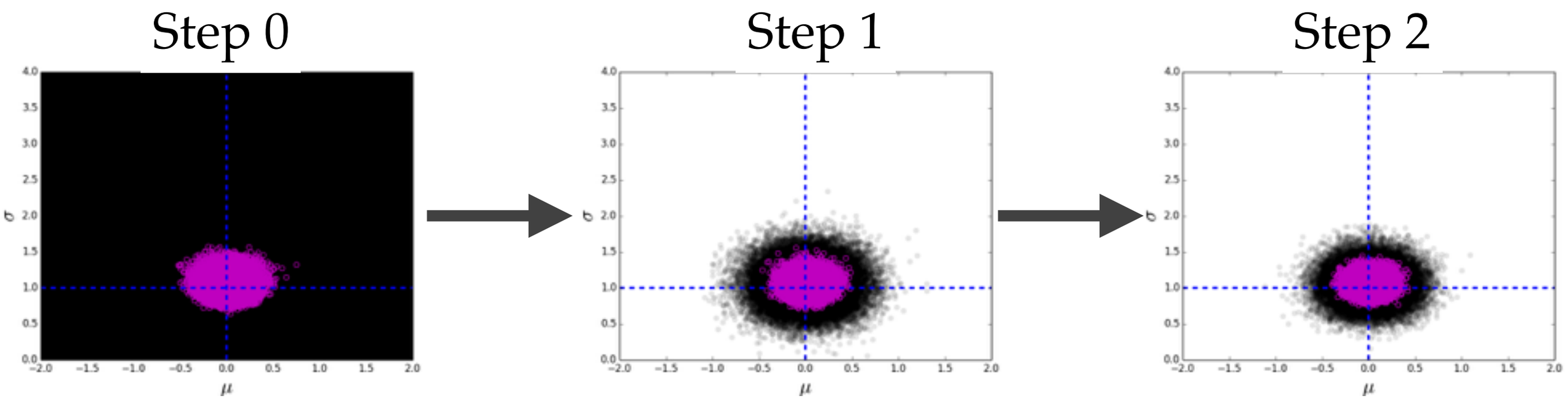


$$\mu = 0.0$$

$$\sigma = 1.0$$

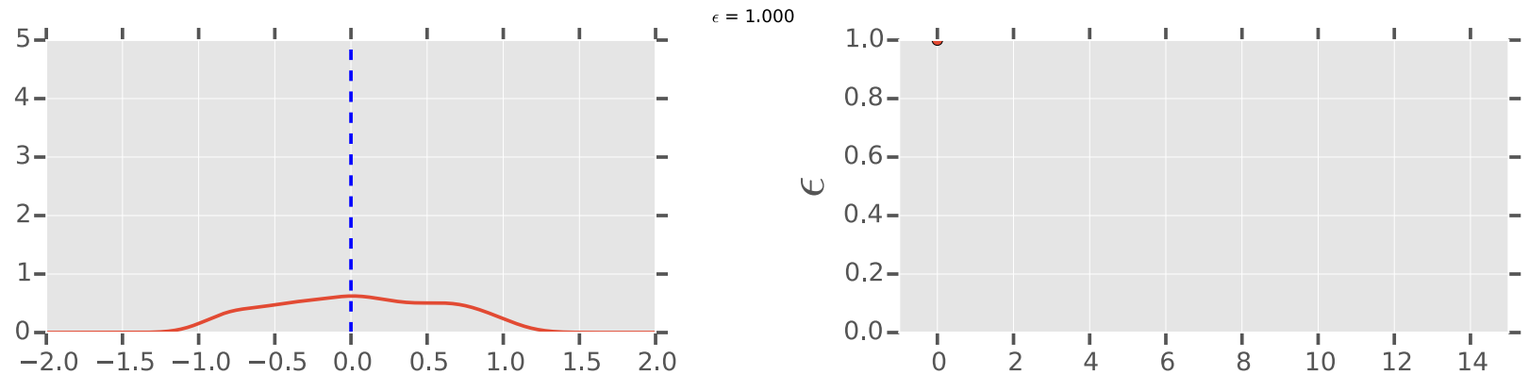
$$\text{Tolerance } (\varepsilon) = 1$$

We can use a sequential population Monte Carlo method to ample more efficiently and shrink the tolerance.

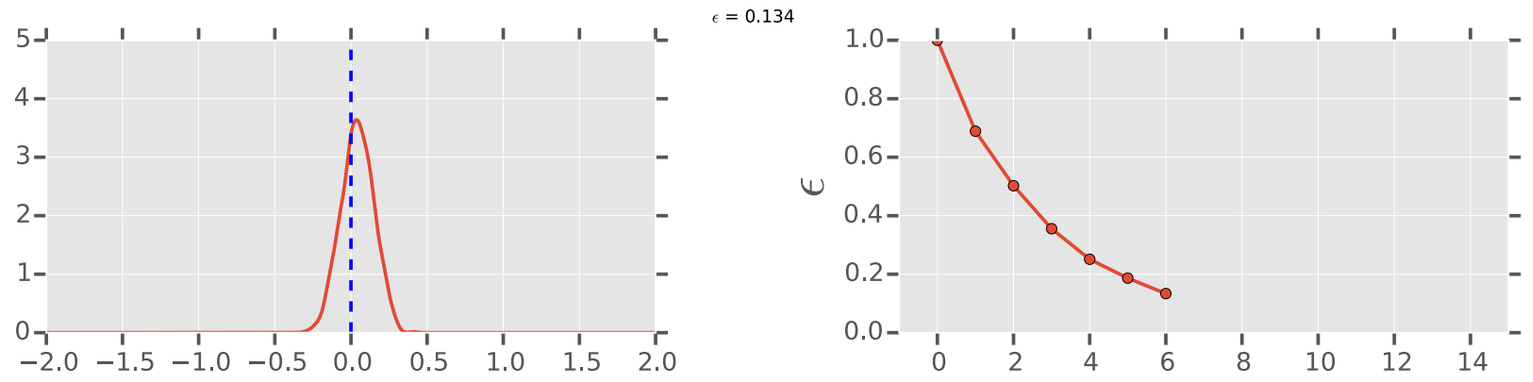


As ε shrinks the posterior distribution approximation is better.

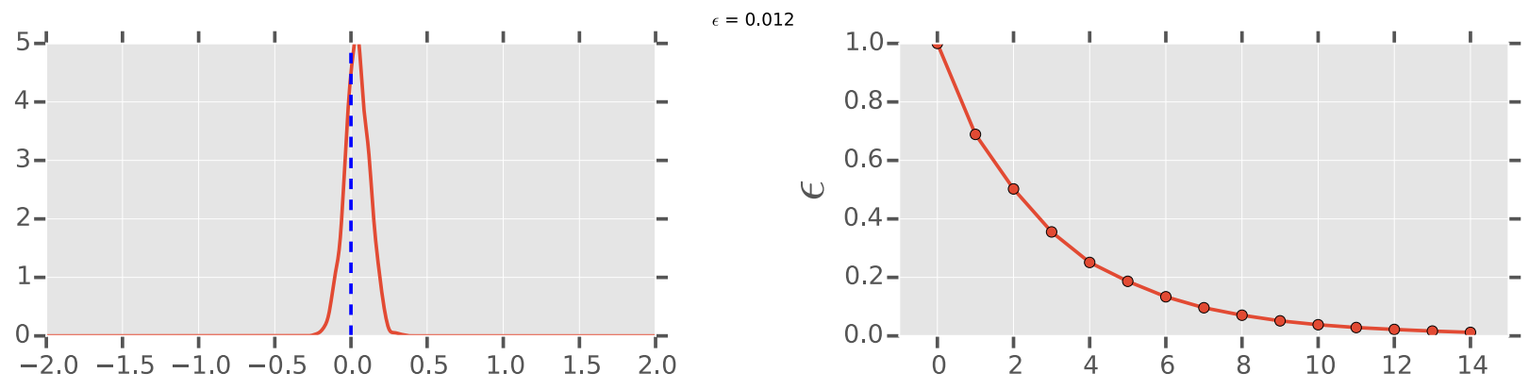
Step 0



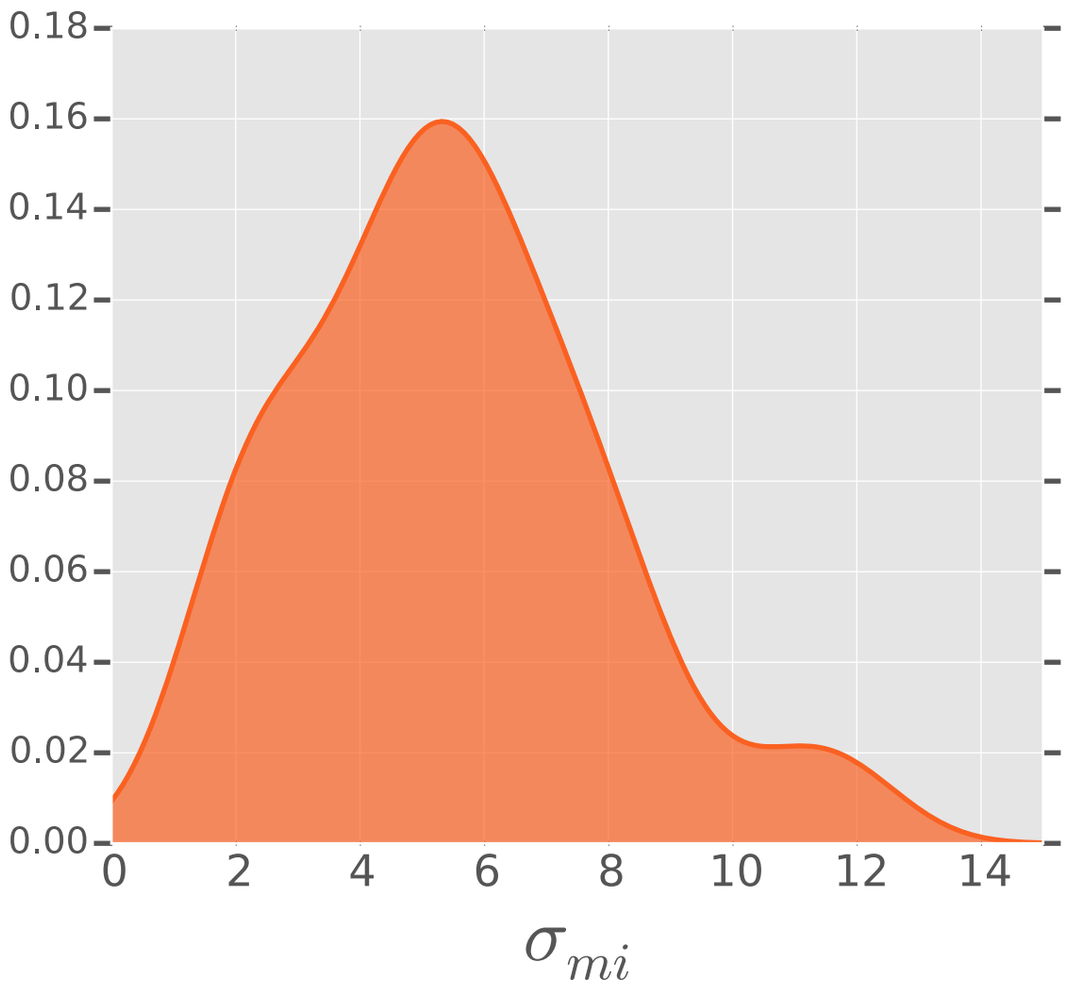
Step 7



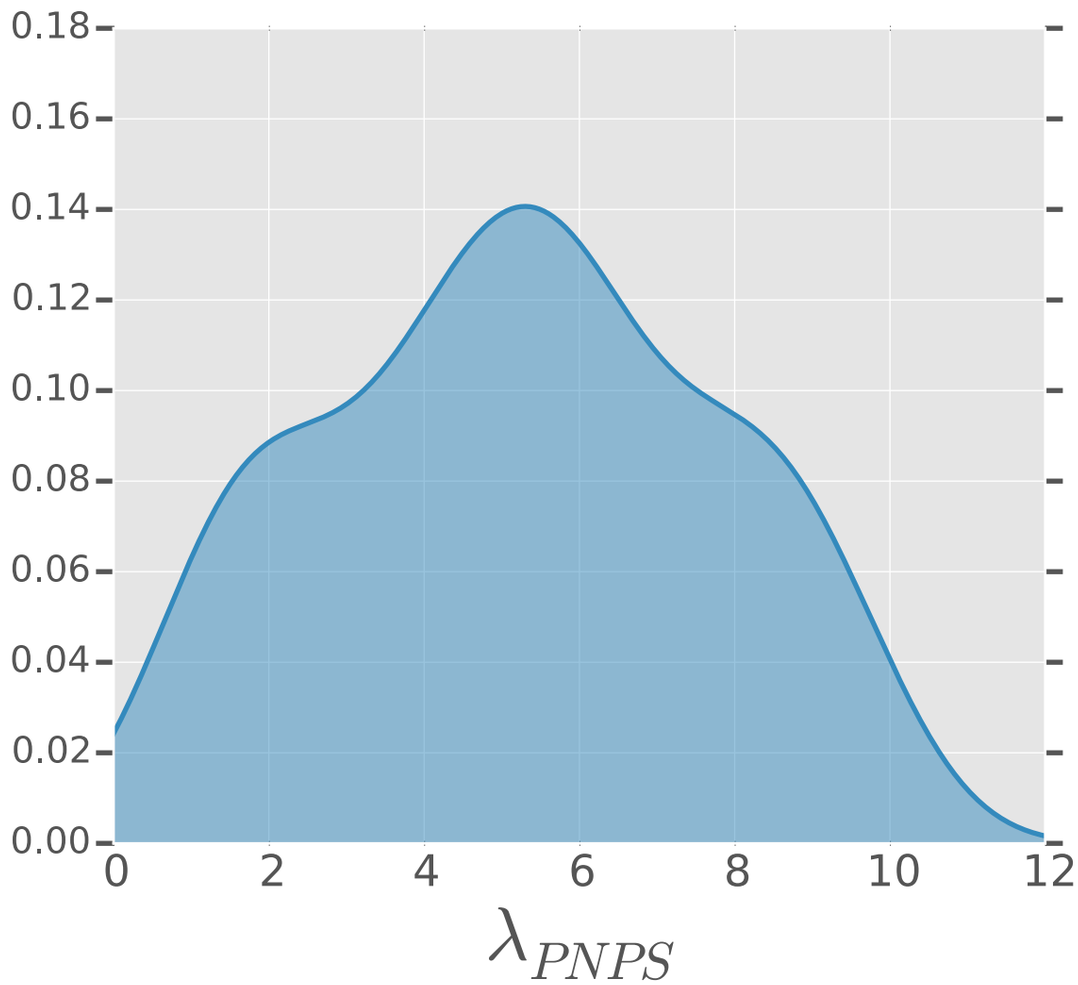
Step 14



A simple model of exoplanets.



σ_{mi} = 4.76 +2.93/-1.97 degrees



λ_{PNPS} = 6.50 +1.60/-4.30

Use with ABC caution!

- You results can be influenced by your selection of summary stats, tolerance and distance function.

- **ABC is not a carte-blanche replacement for likelihood-based methods!**

SimpleABC is available on Github.

https://github.com/rcmorehead/simpleabc