

# Introduction to the Course

## Models for Socio-Environmental Data

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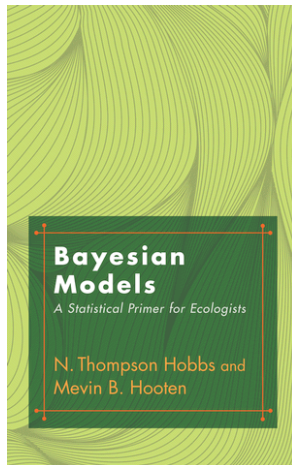
# Housekeeping

- Introductions
- Website for course materials
- Getting notes just in time
- Daily schedule
- Lecture / exercise mix

# Pace

- Working in groups
- Questions, questions, questions
- Advanced problems
- A flexible schedule
- Opportunity to read and study

# Readings

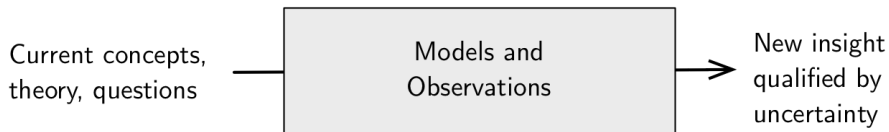


Errata and explanations can be found [here](#)

# Exercise

What do statements made by journalists, attorneys, and scientists have in common? What sets the statements of scientists apart?

# What is this course about?



# What is this course about?

Gaining insight about socio-ecological systems by building models

$$[z_i \mid \theta_p]$$

and fitting those models to data

$$[y_i \mid z_i, \theta_d]$$

using Bayesian methods.

# Goals

- Provide *principles* based understanding
- Enhance intellectual satisfaction
- Foster collaboration
- Build a foundation for self-teaching



# Learning outcomes

- Explain basic principles of Bayesian inference.
- Diagram and write out mathematically correct posterior and joint distributions for Bayesian models.
- Explain basics of the Markov chain Monte Carlo (MCMC) algorithm.
- Use software for implementing MCMC.
- Develop and implement hierarchical models.
- Evaluate model fit.
- Understand papers and proposals using Bayesian methods.

# Learning outcomes

## A. Design

Existing theory, scientific objectives, intuition

Write deterministic model of process.

Design / choose observations.



## B. Model specification

Diagram relationship between observed and unobserved.

Write out posterior and joint distributions using general probability notation.

Choose appropriate probability distributions.



## C. Model implementation

Write full conditional distributions.

Write MCMC sampling algorithm.

Or Write code for MCMC software.

Implement MCMC on simulated data.

Implement MCMC on real data.



## D. Model evaluation and inference

Posterior predictive checks

Probabilistic inference from single model

Model selection, model averaging

# Topics

## Day 1 - 2

### Principles

- Rules of probability
- Distribution theory
- Likelihood
- Moment matching
- Bayes' theorem
- Conjugate priors

## Day 3 - 8

### Implementation

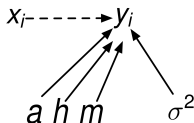
- MCMC
- JAGS
- Regression
- Hierarchical models
- Model checking

## Day 9 - 11

### Advanced topics

- Model selection
- Designed experiments
- Mixture models
- Ordinal regression
- Dynamic models
- Spatial models
- Individual problems

## Cross cutting theme



$$\mu_i = \frac{mx_i^a}{h^a + x_i^a}$$

$$[a, h, m, \sigma^2 \mid \mathbf{y}] \propto \prod_{i=1}^n [y_i \mid \mu_i, \sigma^2][a][h][m][\sigma^2]$$

```
model{
  a ~ dnorm(0, .0001)
  m ~ dgamma(.01, .01)
  h ~ dgamma(.01, .01)
  sigma ~ dunif(0, 5)
  for (i in 1:length(y)){
    mu[i] <- (m * x[i]^a) / (h^a + x[i]^a)
    y[i] ~ dgamma(mu[i]^2 / sigma^2, mu[i] / sigma^2)
  }
}
```