

Today

- Miscellaneous
 - HW feedback
 - Stan installs
- Recap & questions from homework
- Maybe an example to work on

Reproducible workflows

- Reproducible analysis reports
 - not necessary but nice
 - supplementary material, data repositories
- Reports from .R files
- Any .R file can be knitted
- Can also include markup
 - e.g. 05_6_bootstrap_p-value.R

McElreath Ch8

- Learning goals:
- Understand and use **MCMC algorithms** to sample from the posterior distribution
- Recognize and fix bad sampling scenarios
- Use **HMC** implemented in Stan via R packages

Main points McElreath Ch8

- **MCMC**: Monte Carlo Markov Chain
- Series of random numbers where each number **depends** on the previous one
- Sample less from low probability areas; more bang for your random buck
- Algorithms
 - Metropolis-Hastings
 - Gibbs sampling
 - **HMC**: Hamiltonian Monte Carlo
- We'll mostly use HMC

MCMC algorithms

- Basic algorithm
 - propose a new value for parameter
 - what is its probability compared to the current value? ($P = \text{prior} * \text{likelihood}$)
 - accept or reject the proposal in proportion to the proposal/current ratio
- Get an intuition for their behavior:
- <https://chi-feng.github.io/mcmc-demo/app.html#HamiltonianMC,standard>

Bayesian tools

- Stan
 - Gelman group
 - Hamiltonian Monte Carlo
 - Betancourt (2017) A conceptual introduction to Hamiltonian Monte Carlo (<https://arxiv.org/abs/1701.02434A>)
 - open source
 - models with continuous parameters only
 - state of the art
- <http://mc-stan.org>

Bayesian tools

- BUGS (Bayesian inference Using Gibbs Sampling) (and Metropolis-Hastings)
- <http://www.openbugs.info>
- Older, original standard tool for MCMC
- Exceedingly difficult to run on Mac
- Many newer tools are based on BUGS code style
- Lots of books and publications use BUGS
- Recommend: need to know about historically but don't use anymore

Bayesian tools

- JAGS (Just Another Gibbs Sampler)
- <http://mcmc-jags.sourceforge.net/>
 - cross platform, open source
 - basically the same as BUGS
 - often faster
 - highly recommended for models that can't be fit in Stan (e.g. discrete parameters)
 - easy install
- Best to run from R
 - Install R2jags package (install from R)

Bayesian tools

- Others:
- Nimble
 - somewhat common in ecology
- Julia: Turing package

Main points McElreath Ch8

- Using **HMC** via **Stan** to fit models
- Now getting **posterior samples** from **HMC**
- First use `map2stan` in `rethinking` to do HMC to follow examples. Same syntax as `sampost` or `map`
- **rstanarm** does the same
 - Stan group's linear models package
 - syntax like `lm`

Main points McElreath Ch8

- **rstanarm** also uses Stan, HMC
 - Stan group's linear models package
 - syntax like lm
 - sensible default priors

map2stan or sampost

```
m1 <- map2stan(  
  alist(  
    y ~ dnorm(mu, sigma),  
    mu <- a + b * x,  
    a ~ dnorm(0, 100),  
    b ~ dnorm(0, 10),  
    sigma ~ dcauchy(0, 2)  
  ),  
  data=d1)
```

rstanarm

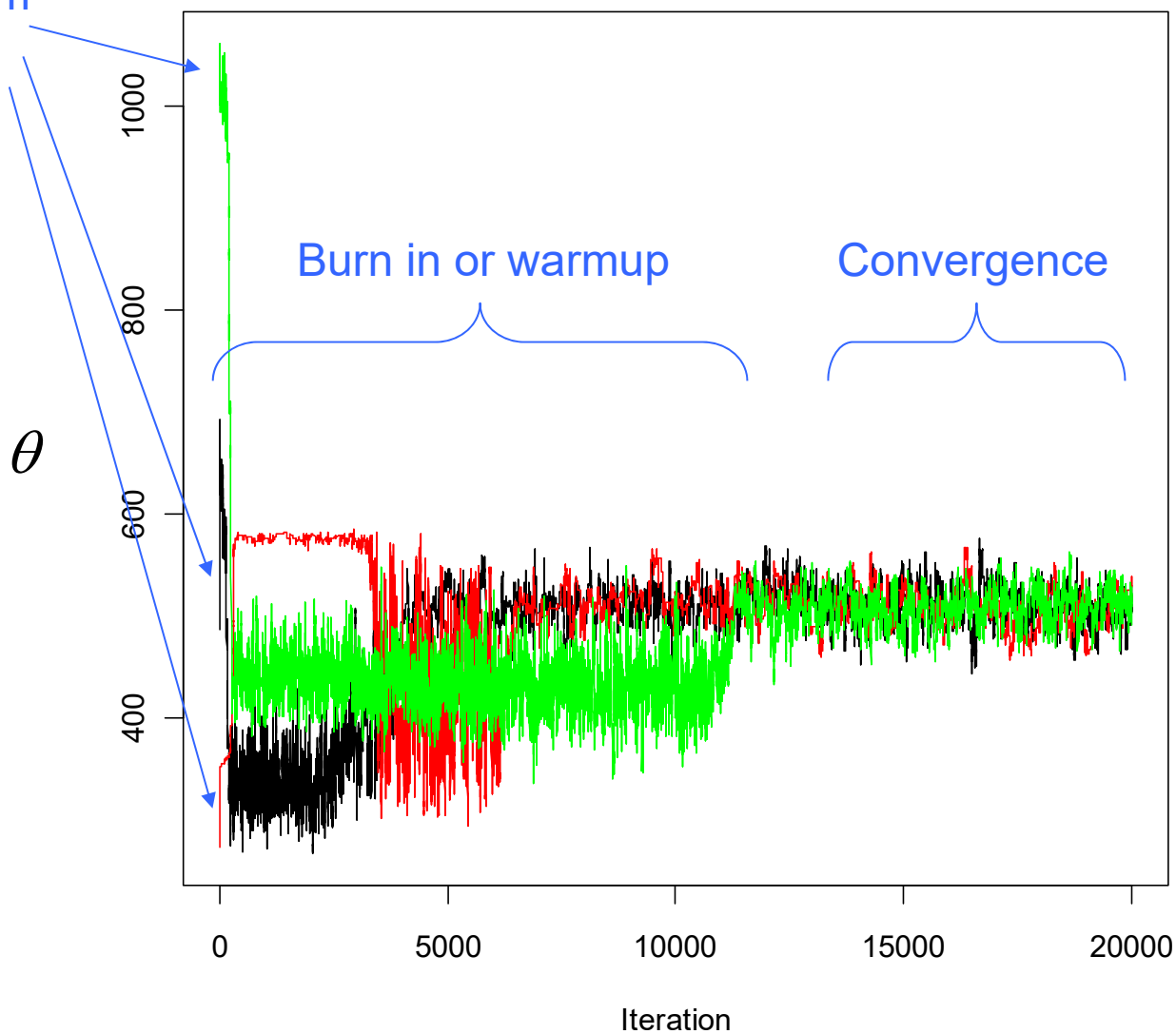
```
m1 <- stan_glm(y ~ b, data=d1)
```

Main points McElreath Ch8

- Good choice of priors (**weakly informative**) can be helpful to tame model fit
 - e.g. **Half-Cauchy** instead of uniform
- Look at MCMC **diagnostics** to judge convergence of fit
 - rhat, n_eff
 - plot chain traces ("time series")
- **Visualize** posteriors
 - histograms, pairs plot

Chains

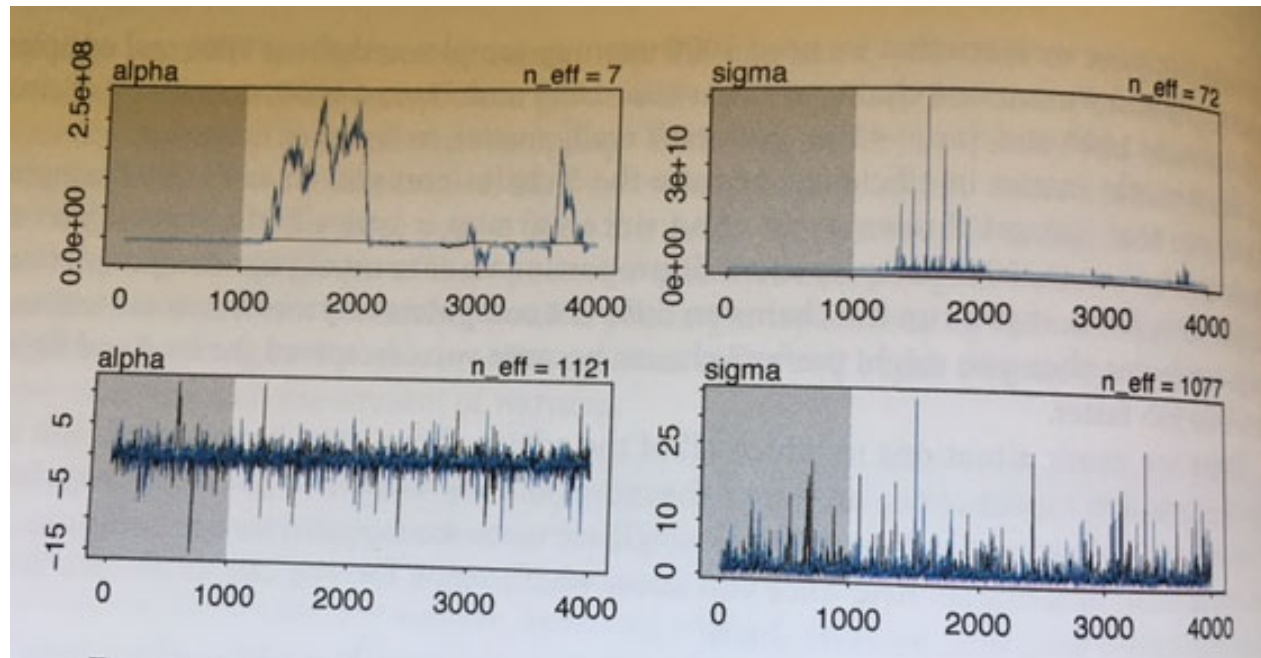
Random
starts



3 chains

Chains

Bad

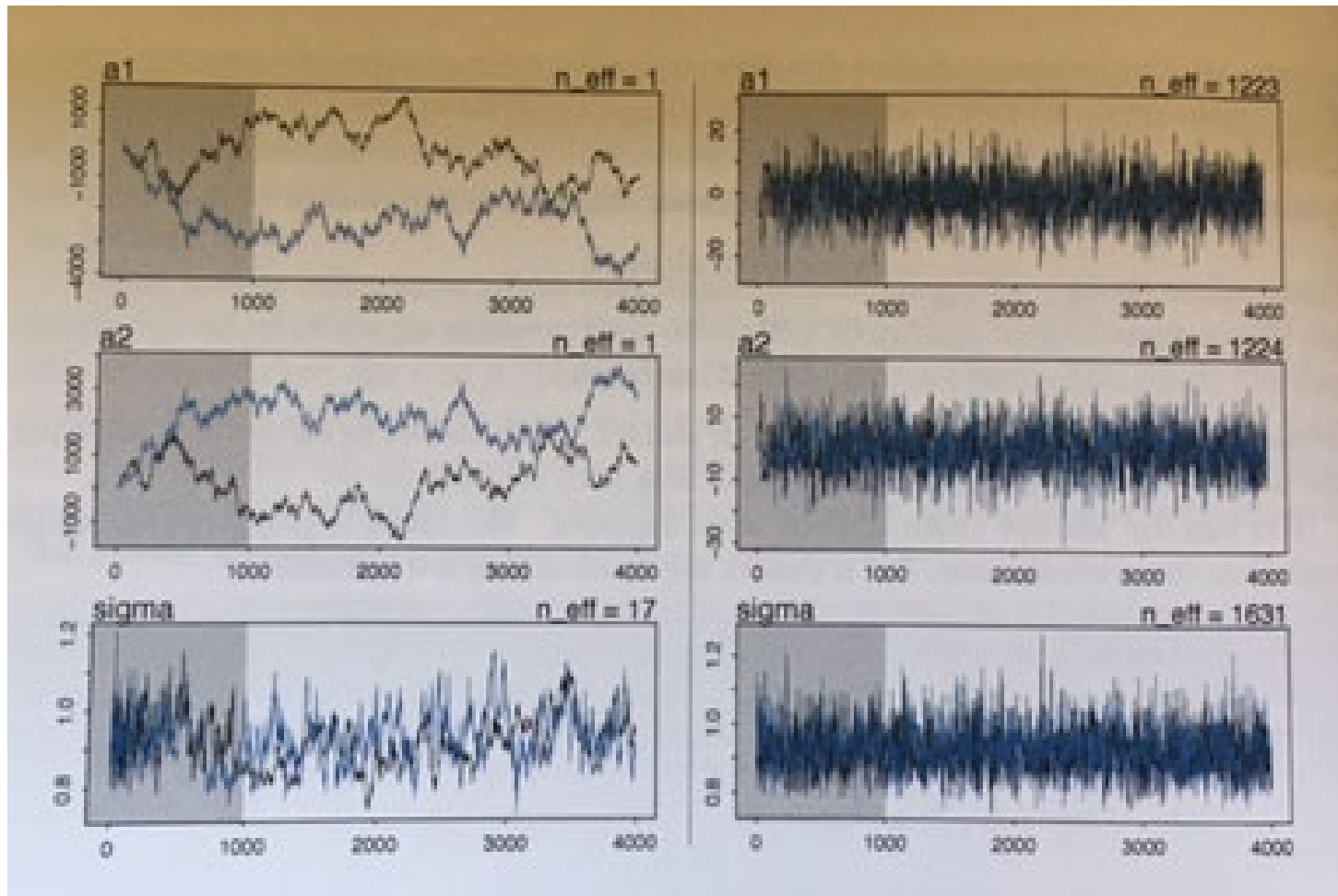


Good

Chains

Not converged

Converged



How to fix

- Better starting values
- Weakly informative priors
- Less common: adjust MCMC algorithm parameters