MCMC Posterior Probability Methods

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- better characterizes parameter uncertainty
 - yields full marginal posterior distribution
 - .std file uses multivariate normal assumption and "delta" method
- captures uncertainty for any model output
 - not just parameters and sd_report variables
- want distribution of OFL for p* ABC
 - using the PPD captures full model uncertainty
 - projection model only captures some uncertainty (e.g., starting biomass)

What does MCMC (Markov Chain Monte Carlo) do?

- ideally, want to integrate over the model's PPD to get the marginal posterior distribution for any desired quantity
- generally, too many parameters to do this using standard integration techniques
- MCMC randomly samples desired quantities using the model's PPD to determine relative sampling rates
 - areas with "high" PPD should have many samples taken
 - areas with "low" PPD should have few samples taken
 - sampling should cover the "entire" PPD
 - for ADMB models, the PPD is based on the objective function = likelihood + priors + constraints

MCMC Methods: Metropolis-Hastings Random Walk Method (MHRWM)

- standard method in ADMB
- runs single chain from MLE solution
- requires multiple runs for multiple chains
 - all start at MLE solution
- can require substantial time for complex models
 - long "burn in"
 - substantial thinning of samples for independence
 - can get trapped near local maxima for long times

MCMC Results from the 2017 Tanner crab OFL Calculation

- MCMC used MHRW Method
- 1 chain
- ~3 days to run ~4.4 million iterations
- thinned by factor of 1000
 - ~4,400 samples from PPD

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MCMC Results from the 2017 Tanner crab model







MCMC Results from the 2017 Tanner crab model







MCMC Analysis

- Best practices (?)
 - run multiple chains from "dispersed" starting points
 - assess convergence of sampling
 - Potential Scale Reduction Factor (\hat{R})
 - compares between-chain to within-chain variability
 - Geweke z-score statistic
 - compares first, last parts of single chain
 - trace plots
 - autocorrelation plots
 - cross correlation
- R Packages
 - coda
 - ggmcmc
 - GGally (pairs plots)

SAFE Reporting Practices: What statistics to report (and when)?

- Tables
 - MLE
 - posterior mean, median, and/or mode?
 - which convergence diagnostics?
- Figures
 - single model
 - MLE
 - posterior mean, median, and/or mode?
 - posterior distribution?
 - which convergence diagnostics?
 - multiple models/quantities
 - MLEs
 - posterior means, medians, and/or modes?
 - posterior distributions?

MCMC Methods: No U-Turn Sampler (NUTS)

- new in ADMB 12 (released Dec., 2017)
- seems to have better sampling/coverage properties than MHRWM
 - better "burn in"
 - sampling more uncorrelated
 - faster
- R package "adnuts" generates multiple chains for ADMB model