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Comment on Article by Vernon et al.

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1 Introduction

The authors are to be congratulated on their presentation of a detailed and comprehensive case study. It is clear that this effort represents a large amount of work by both statisticians and cosmologists. The important topic of statistical inference from complex non-linear deterministic simulation models has received a lot of attention over the last 20 years, and this paper attempts to deal with the many sources of uncertainty in a formal and novel manner, while providing an interesting description of galaxy formation.

I would like to focus this discussion on just one aspect of the paper, that of Bayesian inference for parameters linked by a deterministic simulator (Galform in this case).

2 Pragmatic compromise in Bayesian analyses

The authors employ their Bayes linear approach in this application. Based solely on a specification of means, variances and covariances, it is simpler to implement in complicated problems where a fully Bayesian analysis may be intractable. They describe the Bayes linear approach as a "pragmatic compromise" to a fully Bayesian solution, given a) the difficulty in eliciting a full joint prior probability distribution, and b) the technical challenges in implementing a massive MCMC or similar analysis. These are very valid points, and I am reminded of my own experience with an application in marine mammal assessment that shares some similarities with the Galform problem.

2.1 A population dynamics model for bowhead whales

Population growth for marine mammals is often modeled using a deterministic simulation model, usually a highly non-linear set of differential equations. Given a set of inputs to this model (fecundity, survival rates, pre-exploitation stock size, maximum sustainable yield, etc.) and a known commercial catch history, the population is projected through time from the start of the commercial fishery to the present time where a series of abundance estimates from surveys is typically available. Similar to Galform, the challenge is to find combinations of the inputs that are scientifically plausible, do not lead to extinction, and which produce population trajectories (over time) that match the current data on abundance and rates of increase.

In the 1990's the International Whaling Commission used a model named BALEEN II for assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales, *Balaena mysticetus*. Further background and history are given in Raftery et al. (1995), who also

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