Calibrating process-based models using several data sources and Approximate Bayesian Computation: illustration with a forest simulation model

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Abstract: Ecological research increasingly relies on model-based inference. Often, models are too complex, or available data too coarse, so that standard likelihood-based methods cannot be used to estimate the model parameters. In those cases, a number of likelihood-free methods have been proposed. However, these methods rely on intensive model simulations, so that most applications have been restricted to relatively simple models with few parameters. In this study, we were interested in the use of such methods with more complex models involving a large number of parameters. Our case study was the calibration of the individual-based forest model Samsara2. The initial model calibration, carried out with detailed data, was used to estimate prior knowledge. Low-informative data coming from historical management were then used to test the limitations of current Approximate Bayesian Computation (ABC) approaches. We addressed three questions: (1) Is it possible to reach a reasonable posterior approximation of model parameters with a drastically limited number of simulations and relatively coarse data? (2) How many model parameters can be estimated with this approach and is this number limited by the number of simulations? (3) How much estimated parameters uncertainty is increased when propagating other model parameters uncertainties? With a relative small number of simulations and an appropriate choice of the model parameters, we demonstrated the relevance of the ABC technique to calibrate a complex model such as Samsara2. Our approach illustrates how detailed knowledge on ecological processes drawn from the literature or from detailed field studies can be combined with more widely available coarse data to calibrate complex mechanistic models. This approach potentially enables to perform the calibration of complex models to a large number of field sites, for which coarse data are available, instead of being restricted to the few sites were detailed studies have been conducted.