Emulation methods for Approximate Bayesian Computation



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ABC in a nutshell



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Advantage: description of parameter uncertainty/correlation/multi-modality

Disadvantage: slower than optimization

ABC can work well...





Jabot & Chave Ecol. Lett. 2009

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Efficient algorithms to speed up ABC in the R package EasyABC

- sequential techniques (Beaumont et al. 2008, Del Moral et al. 2012, Lenormand et al. 2013)

- coupling to MCMC (Marjoram et al. 2003, Wegmann et al. 2009)

(+post-processing treatments (Beaumont et al. 2002))

... Still prohibitive for very costly simulators

Jabot, Faure & Dumoulin MEE 2013

Towards a mechanistic understanding of species interactions in diverse grasslands



- Analysis of plant stochastic community dynamics
- Design of a trait-based plant growth model
- Upscaling from plant growth to community dynamics



Lohier et al. Annals of Botany 2014

Effects of environmental conditions on tree demography



- Approximate Bayesian re-calibration of Samsara2
- Calibration along environmental gradients with forestry data
- Design of « climate change proof » sylvicultural strategies



Guillaume Lagarrigues with B. Courbaud

Lagarrigues et al. Ecological Modelling in press

Emulation methods for Approximate Bayesian Computation



A comparison of emulation methods for Approximate Bayesian Computation



- N model simulations (with N small)
- Fit of the emulator on the N model outputs
- Use of the emulator in the ABC procedure
- **Previous work**: Henderson et al. 2009, Buzbas and Rosenberg 2013, Jandarov et al. 2013, Meeds and Welling 2014, Wilkinson 2014



Jabot JTB 2010

A stochastic model of community dynamics **Regional pool:** θ b а 00 0 4.6 Immigration: m 100 -4.4 In (/)_est h_est 60 4.2 0 4.0 20 Local community 3.8 0 d -20 а 3.8 4.0 4.2 4.4 4.6 4.8 20 40 60 80 100 3.6 n 200 h_sim In (I)_sim Filtering Function d С



80

60

Trait value

40

100

20

0

40

30

20

2

0

0

20

40

80

60

Trait value

100

Local Abundance

Jabot Journal of Theoretical Biology 2010

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Large model stochasticity



Species richness

A first try based on local regressions

Methodology:

- Use of loess (local polynomial regression, degree=2, 100 closest points, tricubic weight function)
- Number of « design points » : 200, 400, 600, 800, 1000
- Use of the emulator on 100,000 novel points in the parameter space
- Comparison with 100,000 simulations of the original model on the same points
- Comparison based on cross-validation:
 - 100 simulations of the original model as 100 virtual datasets
 - ABC based on the 99,999 remaining simulations
 - Using the original model simulations
 - Using the emulator
 - Computation of the predictive error
 - Computation of the average posterior width (95%)

A first try based on local regressions



A first try based on local regressions







0 20000



Still to do

- Incorporating co-variances in the stochastic part of the emulator
 - -> Possibility to perform synthetic likelihood with the emulator (Wood Nature 2010)
- Testing other meta-models (gaussian processes...)

- Merci!