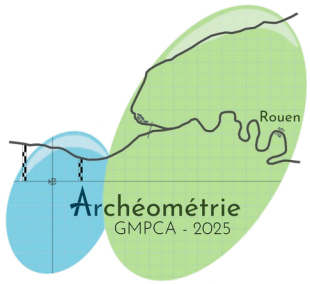

Computational modelling to infer demographic processes and cultural interactions from archaeological evidence: challenge and perspectives

Simon CARRIGNON

Computational model like Agent-Based Models (ABMs), offer highly flexible tools for researchers exploring systems where few theories exist, and data is limited. Archaeology is a great example of such systems. The scarcity and quality of empirical evidence can't be addressed through experimental approaches, and no general theory of human behaviour is available to precisely describe past civilizations.

Computational simulations enable exploration of a vast array of hypothetical scenarios, in a robust and reproducible way, integrating heterogeneous knowledge across multiple levels and where complex interactions can be implemented. However, the flexibility of exploratory models comes at a cost : managing a vast space of possible models that become increasingly complex as more detailed descriptions of the hypothetical processes are added, making them difficult to compare and interpret.

Other computational methods, like Gaussian processes or spatial autoregressive models, deal with this by formulating the problem under a stricter Bayesian framework, constraining the processes modelled to those that can be described by well-known distributions. These methods use simulations for calculating the full posterior distribution of the model under specific archaeological evidence. If they allow precise inference about the processes being modelled, they limit the complexity and the richness that can be expressed. Combining models allowing hypothesis exploration with Bayesian approaches through Approximate Bayesian Computation and Tactical Simulations can bring together the best of both worlds, effectively combining the expressivity of exploratory models with statistical robustness. This talk will illustrate the use of such approaches to understand demographic and cultural processes across various archaeological contexts from the Roman Empire to the first mega-settlements in Eastern Europe and the spread of agriculture in Japan. It will highlight the importance of standardised and easy to access archaeological dataset, through the example of BIAD (Big Interdisciplinary Archaeological Database) to ensure the success of these methods, and will review the challenges that remain to be addressed. Overall, this workflow – centred around computational modelling and facilitated by easy access to computational power and advanced AI tools – has the potential to radically transform part of archaeology, by leveraging the combination of standardised large datasets, generative models and strong statistical analysis.