

Modelling Gaia
towards an Actor-Network modelling framework in archaeology

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A NETWORK FOR AGENT-BASED MODELLING OF SOCIO-ECOLOGICAL SYSTEMS IN ARCHAEOLOGY (NASA)

Theme: 5. Assembling archaeological theory and the archaeological sciences

Organisers: Verhagen, Philip (Vrije Universiteit Amsterdam) - Daems, Dries (KU Leuven) - Romanowska, Iza (Aarhus University)

Format: Session with keynote presentation and discussion

Agent-based modelling (ABM) has developed into an important methodological tool in archaeological research. ABM allows us to simulate the dynamics of complex systems, hypothesize individual and collective action, and investigate socio-ecological processes at various scales. It represents a veritable paradigm shift, not just for the study of the human past but also for the social sciences in general.

Formal modelling tools such as ABM have several advantages over more informal approaches to study complex dynamics in past human and environmental systems. They 1) enforce conceptual clarity, 2) define mechanisms of change, 3) help infer dynamics in the past from the static archaeological record, and 4) allow for rigorous hypothesis testing.

Applications in archaeology have been growing in number in recent years, but ABM is yet to fully mature as a conceptual and methodological tool for studying the past. To make this maturation possible, we need to encourage wider dissemination among researchers and the establishment of standardized practices. An important step forward was the recent foundation of the Network for Agent-based modelling of Socio-ecological systems in Archaeology (NASA). The main targets of this network are: 1) compile a curated model library for ABM in archaeology; 2) collect and develop best practices and modelling guidelines; 3) develop tools for interoperability following the FAIR principles; 4) create a network for international collaboration.

We invite researchers working on archaeological ABM to present their work and contribute to the goals of the network. Contributions can consist of, but may not be limited to:

- individual case studies highlighting a specific issue, method or solution;
- proposals including demos of ABM modules that can form part of the modelling library;
- examples of integration of ABM with other (archaeological) methods;
- standards and best practices in ABM, as well as directions for the current and future development.

ABSTRACTS:

1 REASSESSING THE ROLE OF CLIMATE CHANGE IN THE EXPANSION OF AMAZONIAN FARMERS DURING THE LATE HOLOCENE

Abstract author(s): Gregorio de Souza, Jonas - Madella, Marco (Universitat Pompeu Fabra)

Abstract format: Oral

During the late Holocene, the archaeological record of lowland South America shows the emergence and dispersal of ceramic traditions associated with polyculture agroforestry (forest farming). Such expansions coincide with the distribution of the largest language families in the continent. At the same time, starting ca. 4-3 ka, wetter conditions drove the advance of forests in regions affected by the South American summer monsoon. The coincidence between precipitation increase, forest expansion and population dispersal has long suggested that the establishment of modern climate conditions favoured the expansion of tropical forest farmers and their languages. Here, we employ a computational approach to test the role of climate change in determining the rhythm of advance and the routes taken by populations expanding from the Amazon to other parts of South America. We simulate demographic-diffusion processes in an agent-based model informed by the dynamics of growth, fission and movement of Amazonian villages interacting with a dynamic environment that reproduces shifts in landcover based on interpolated fossil pollen data.

2 AN ABM APPROACH TO THE NEOLITHIC SPREAD IN EUROPE AND AN ANCIENT GENETIC CLINE

Abstract author(s): Fort, Joaquim - Pérez-Losada, Joaquim (Universitat de Girona)

Abstract format: Oral

We report an agent-based modelling (ABM) approach of Neolithic spread and compare it to archaeological and genetic data. This ABM approach uses integer numbers for the population sizes, so it is more realistic than a previous approach (Isern, Fort and de Rioja, Sci. Rep. 2017). However, implementing this feature is not straightforward and we will explain the difficulties and solutions that we have applied. Our new ABM approach correctly reproduces the arrival times of the Neolithic at several regions of the Near East and Europe, as well as the cline of mitochondrial haplogroup K that has been detected using ancient DNA data. We discuss the implications of our ABM model on the dispersal and interbreeding behaviour of farmers and hunter-gatherers. We also discuss differences along the two main routes of Neolithic spread, namely an inland route along the Balkans and central Europe and a coastal route along the Northern Mediterranean coast.

3 EXPLORING ENVIRONMENTAL DETERMINISM WITH AGENT-BASED MODEL OF SETTLEMENT CHOICE

Abstract author(s): Sikk, Kaarel (University of Luxembourg)

Abstract format: Oral

Archaeology and the related fields of geography and anthropology have a long history of debate of environmental determinism going beyond discussing methodological issues. The environment's influence on social processes has always been an important component of archaeological interpretations. Several research tools are completely dependent on the concept, for example it is essential for archaeological site locational modelling both in case of deductive and inductive models.

Studies using empirical inductive models have proven the significance of environmental effects of various spatial processes observed in archaeological material. Those works have resulted in models with varying predictive power, therefore a lot of emphasis has been put on advancing algorithms and model training. It has also been discussed that systemic properties of past human-environment relations like economic intensification, social complexity and spatial configuration of the environment influence the environmental determinism of settlement choice. So far possible influences of those systemic properties have not been quantitatively researched.

In this study possible spatial and systemic effects to environmental influence to settlement choice are explored using Agent-Based Model (ABM). A stylised ABM simulation model of settlement pattern formation is created based on general settlement theories from geography (ekistics) and archaeology. The model includes the generation of synthetic environments and is used to simulate settlement patterns formation as a process of consecutive settlement choice events.

The model is used for testing different systemic properties of human-environmental interactions and their effect on the environmental determinism of settlement choice. It is explored for the sensitivity to various mechanisms of human-environment interactions, population properties and spatial configuration of the environment. It is argued that environmental determinism is valuable information in itself and can be used as an indication of systemic properties of the past. Possibilities for quantifying the environmental determinism of the settlement choice process are explored.

4 MODELING THE LANDSCAPE EVOLUTION AND LAND-USE IN EARLY BRONZE AGE AT HACILAR, IN SW ANATOLIA

Abstract author(s): Arikan, Bulent - Özdoğru, İnci (Istanbul Technical University)

Abstract format: Oral

The mound of Hacilar (Burdur-Turkey) in SW Anatolia was a major settlement during the Early Bronze Age-I (ca. 3100 – 2900 BC). Systematic archaeological research has been going on for the last decade. Excavations at the site revealed a detailed settlement plan. Based on the site's layout, it is possible to calculate the approximate population of the settlement. Combined with paleoenvironmental and paleo-climate research conducted at the site, we now have a comprehensive dataset about its immediate region. This paper will deliver the results of agent-based modeling experiments at Hacilar. Using this diverse set of data for human behavior and past environmental conditions, agent-based modeling has been applied to simulate how dry farming and ovicaprid-based, site-tethered pastoralism affected the immediate landscape around the site. The use of agent-based modeling at this single-period settlement also informs us about the patterns of socio-economic and demographic changes in the long-term. The results of the modeling experiments allow us to understand the processes of socio-political and environmental processes in greater detail.

5 MODELLING GAIA: TOWARDS AN ACTOR-NETWORK MODELLING FRAMEWORK IN ARCHAEOLOGY

Abstract author(s): Ertsen, Maurits (Delft University of Technology)

Abstract format: Oral

Agent-based models have become powerful instruments to explore archaeological questions. Yet, one of the main challenges remains to avoid too much pre-structuring of agent activities in such models. Many modelling approaches are less capable to acknowledge change in activities, as they tend to model patterns of activities (defined as behavior). This hampers our understanding of emergence of change in the settings we are interested in. Discussing examples on Mesopotamia and Jordan, this paper explores how the Gaia approach as provided by the French scholar Latour allows an elegant, robust and theoretically convincing modelling framework. A major decision appears to be how to assign agency to non-humans as well, next to human model agents. The contribution will discuss why and how for cases with different spatial and temporal scales like Mesopotamia (landscape change over thousands of years) and Jordan (irrigation systems within days and/or decades), it does make sense to keep the modelling scales (parameters and time step) similar.

6 SIMULATING ROMAN ECONOMIES

Abstract author(s): Brughmans, Tom (Classical Archaeology and Centre for Urban Network Evolutions - UrbNet, Aarhus University)

Abstract format: Oral

The use of formal modelling and computational simulation (especially agent-based modelling (ABM)) in studies of the Roman economy has become more common over the last decade. This paper will explore why Roman Studies should add these approaches as