Modelling for teaching and research: A network for ABM of SES in Archaeology

DR. DRIES DAEMS

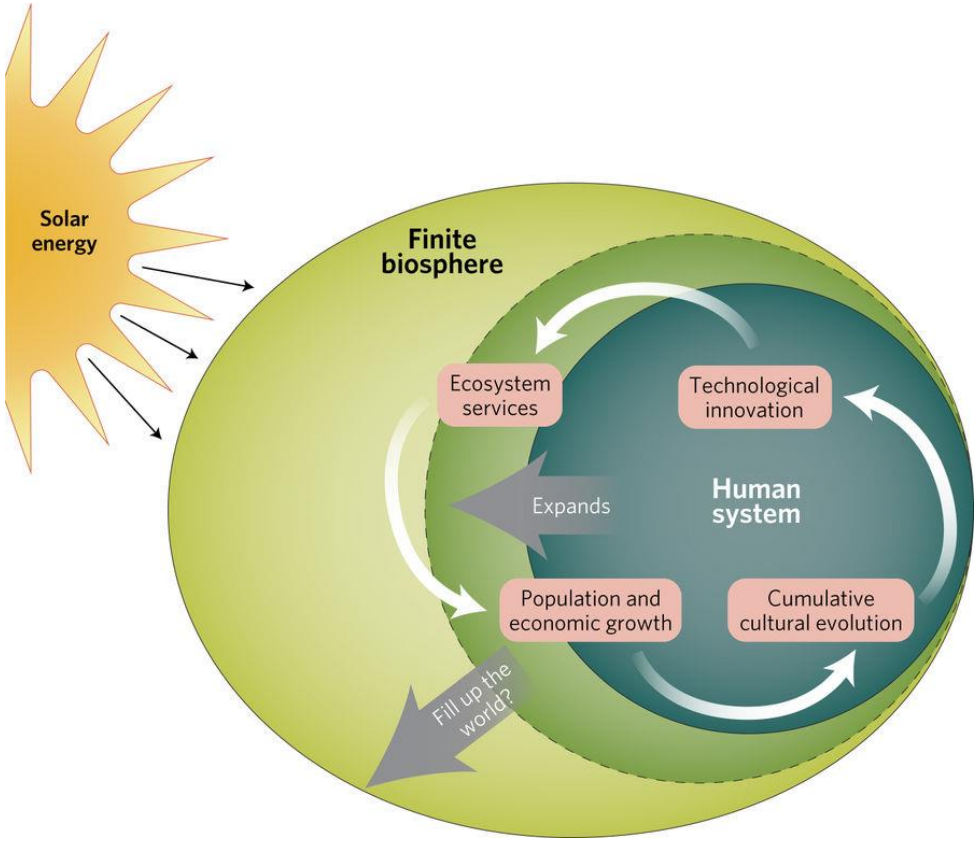
MIDDLE EAST TECHNICAL UNIVERSITY (ANKARA, TURKEY)

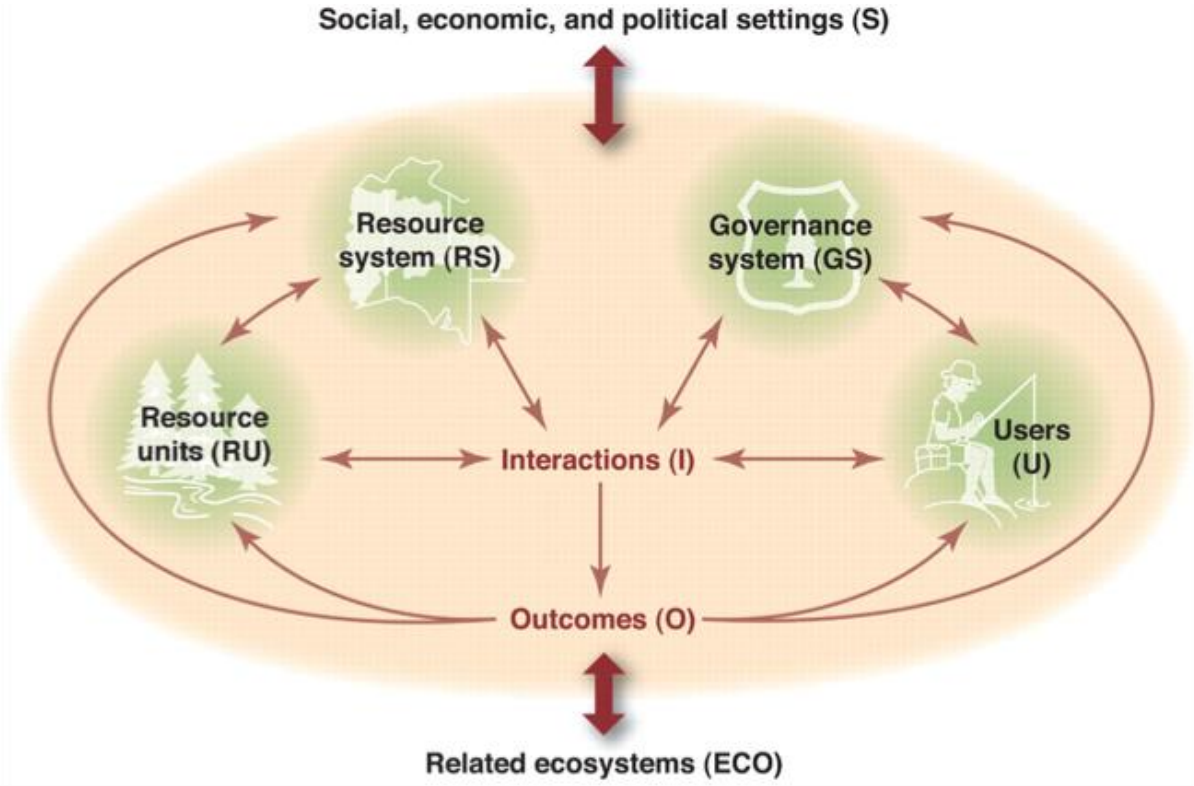
SAGALASSOS PROJECT (KU LEUVEN, BELGIUM)

DAEMS@METU.EDU.TR | TWITTER: @DRIESDAEMS

HTTPS://WWW.DRIESDAEMS.COM

Socio-Ecological Systems (SES)

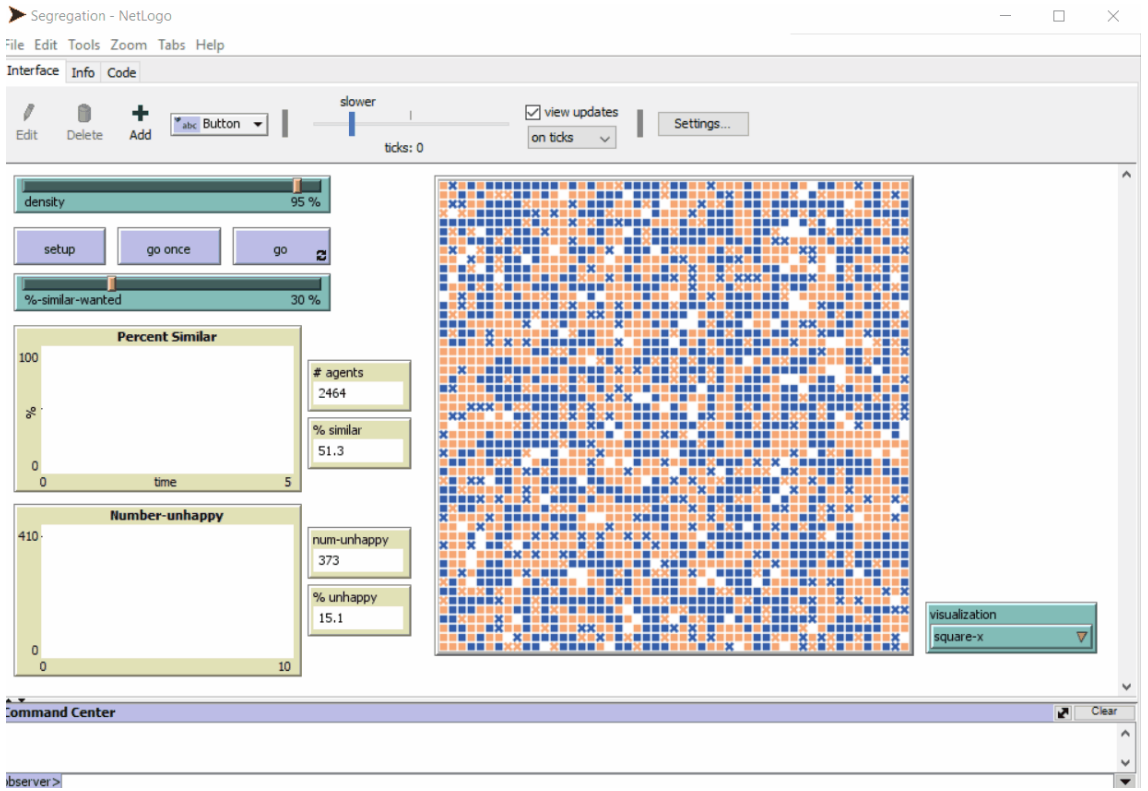




Burger (2018) Modelling humanity's predicament. *Nature Sustainability.*
Ostrom 2009 A General Framework for Analyzing Sustainability of Social-Ecological Systems

What is agent-based modelling (ABM)?

- Method of computer simulation
- Bottom-up approach: Agents as autonomous and heterogeneous entities
- Individual/group-based rulesets that govern actions and interactions
- ABM = simulation of agents, environment and their interactions under a set of rules
  - Traces aggregate characteristics of a system that emerge from the behaviour of its parts

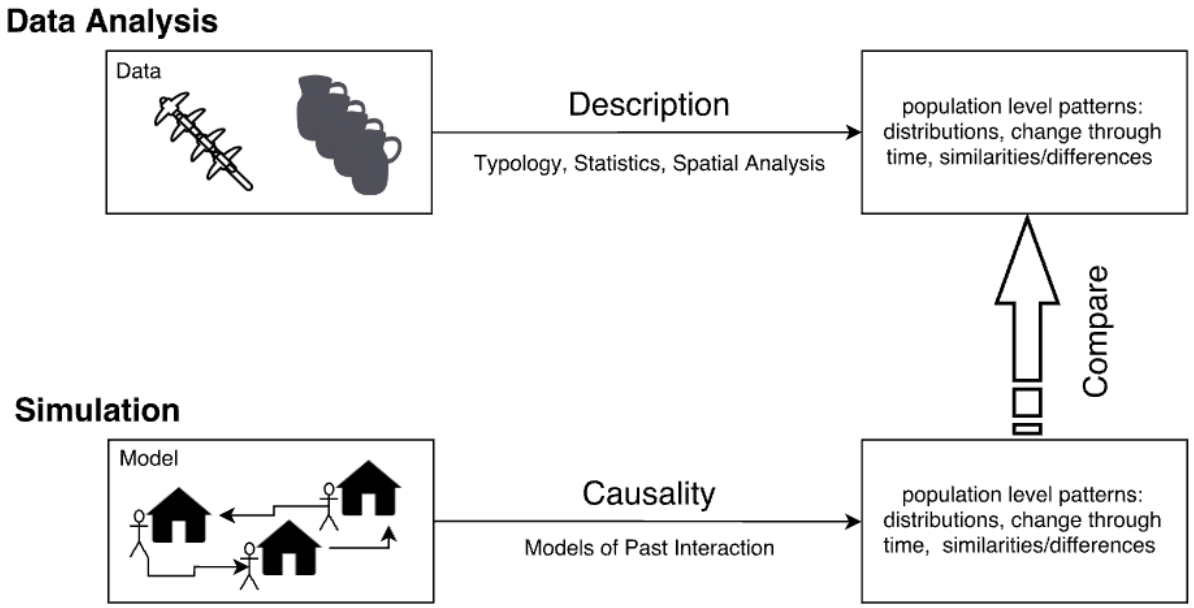


Schelling, T. (1978). *Micromotives and Macrobehavior*. New York: Norton.

Agent-based modelling in Archaeology

ABM as “cultural laboratories”

- Enforcing conceptual clarity
- Understand underlying mechanisms of change
- Infer past dynamic behaviour from static archaeological record
- Rigorous hypothesis testing



Romanowska (2015) So you think you can model?

ABM: Science & creativity

SCIENCE

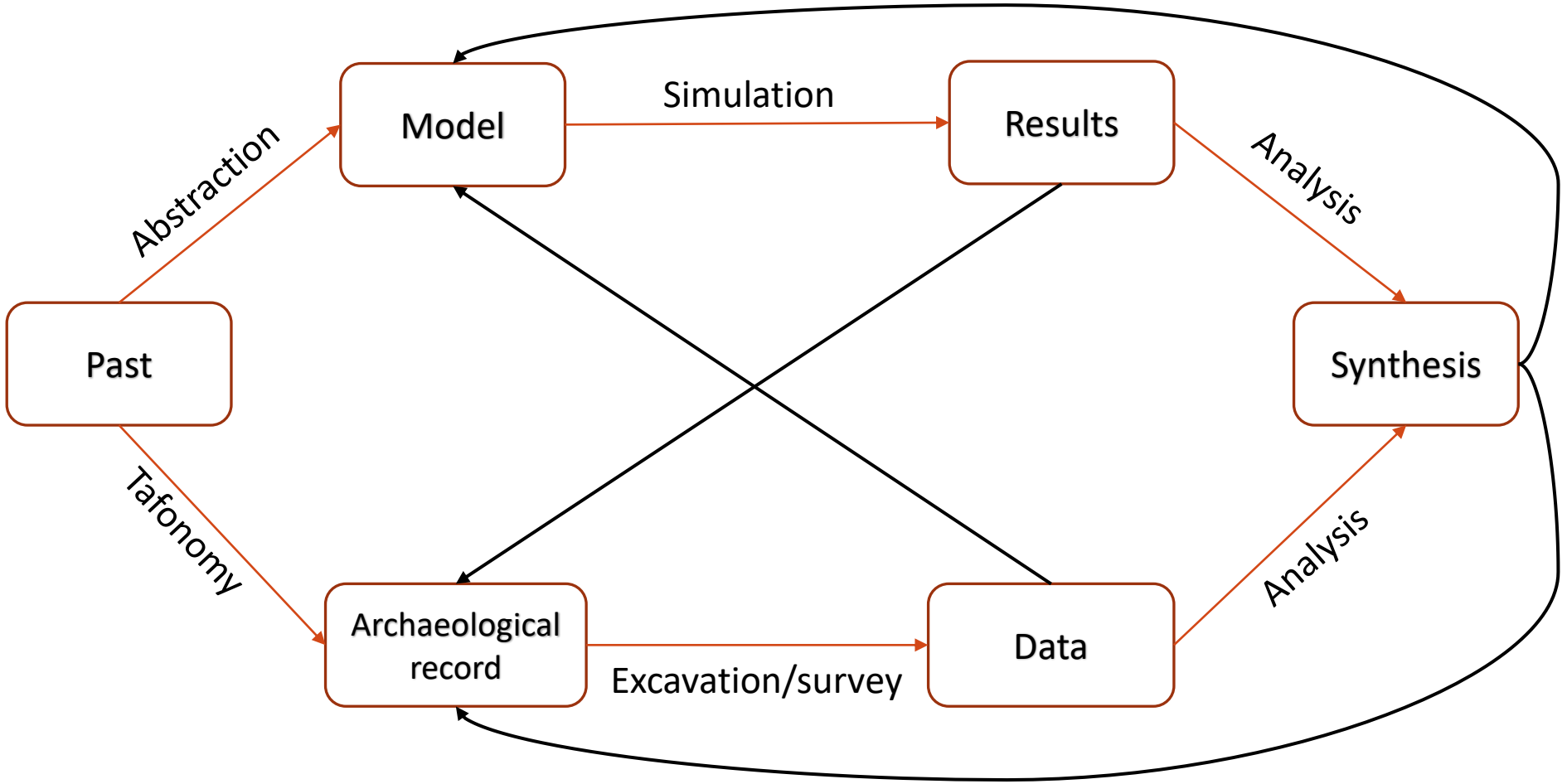
- Bottom-up
  - Emergence from constituent interactions
- Formal approach
  - Conceptual clarity & transparency
  - Hypothesis testing
- Emergence
- Cultural laboratories

CREATIVITY

- Playfulness
- Experimentation
- Imagination

"*What I end up simulating is not the past but the story I am telling about the past*" (Graham 2020, p.12)

Agent-based modelling in Archaeology



Agent-based modelling in Archaeology

- Demography (Axtell et al. 2002; Verhagen et al. 2019)
- Information transmission and cultural evolution (Fort et al. 2016; Premo 2014)
- Cultural and economic transmission (Carrignon et al. 2020)
- Trade networks (Brughmans and Poblome 2016; Chliaoutakis and Chalkiadakis 2020)
- Land use (Verhagen et al. 2021)
- Foraging (Sikk and Caruso 2020)
- Resource use (Coco et al. 2020)
- Taphonomy (Carney and Davies 2020)
- Social complexity and resilience (Angourakis et al. 2020; Cioffi-Revilla et al. 2007; White 2013)
- Environmental stress and social network formation (Shultz and Costopoulos 2019)
- Least-cost analysis and spatial diffusion (Gravel-Miguel and Wren 2018)
- Human mobility and technological innovation (Conrad et al. 2018)
- Population diffusion (Isern et al. 2017)
- Polity formation (Crabtree et al. 2017)
- Raw material procurement (Oestmo et al. 2016)
- Resource distribution (Jassen and Hill 2016)
- Cultural diversity (del Castillo et al. 2014)
- Societal transformation and decline (Heckbert 2013; Janssen 2009)
- Settlement patterns and political consolidation (Griffin and Stanish 2007)

AND MANY MORE…

Agent-based modelling in Archaeology: Where next?

Current state of the field:

- Isolated efforts
- Idiosyncratic
- KISS ~ toy models

Solutions:

- Cumulative efforts
- Integrated approaches
- Collaboration and academic networks

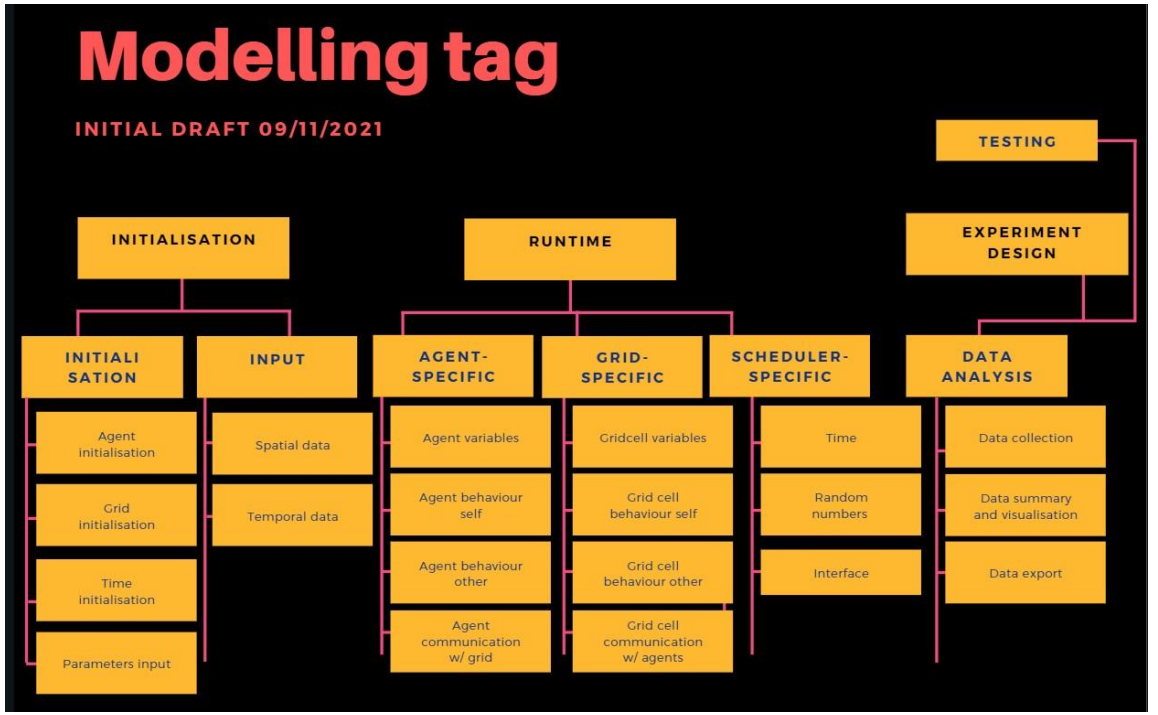
Network for Agent-based Modelling of Socio-Ecological Systems (NAS²A)

Goals:

1) Compile an openly available model library for ABM elements (modules, techniques, implementations, etc.).
2) Collect and develop best practices and modelling guidelines.
3) Develop tools for interoperability following the FAIR principles.
4) Disseminate ABM approaches in archaeology through teaching
5) Create a structure for international collaboration and stimulus

ABM and research: Models Library

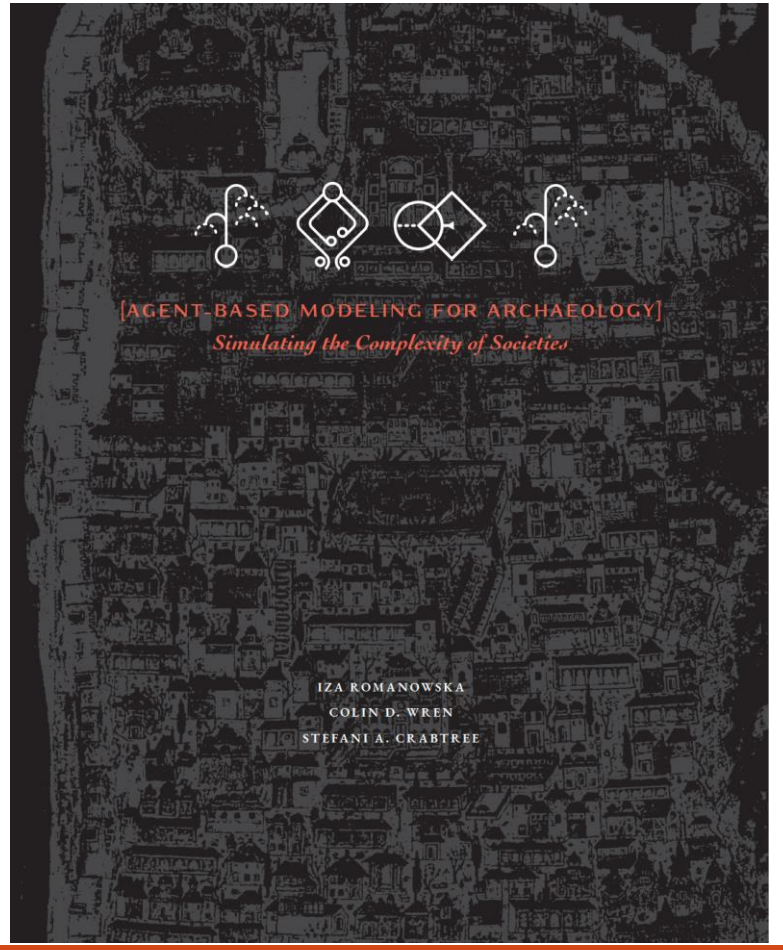
- Set standards
  - Common ontology and metadata
- Produce content
  - Models, algorithms, modules, …
- Ensure integration and interoperability
  - Linking model elements
  - Tagging
  - Categories
- Build infrastructure
  - Interface
  - Online access



ABM and teaching

Recent textbook:

Romanowska, I., Wren, C.D. and Crabtree, S.A., 2021. *Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies*. Santa Fe: Santa Fe Institute Press.



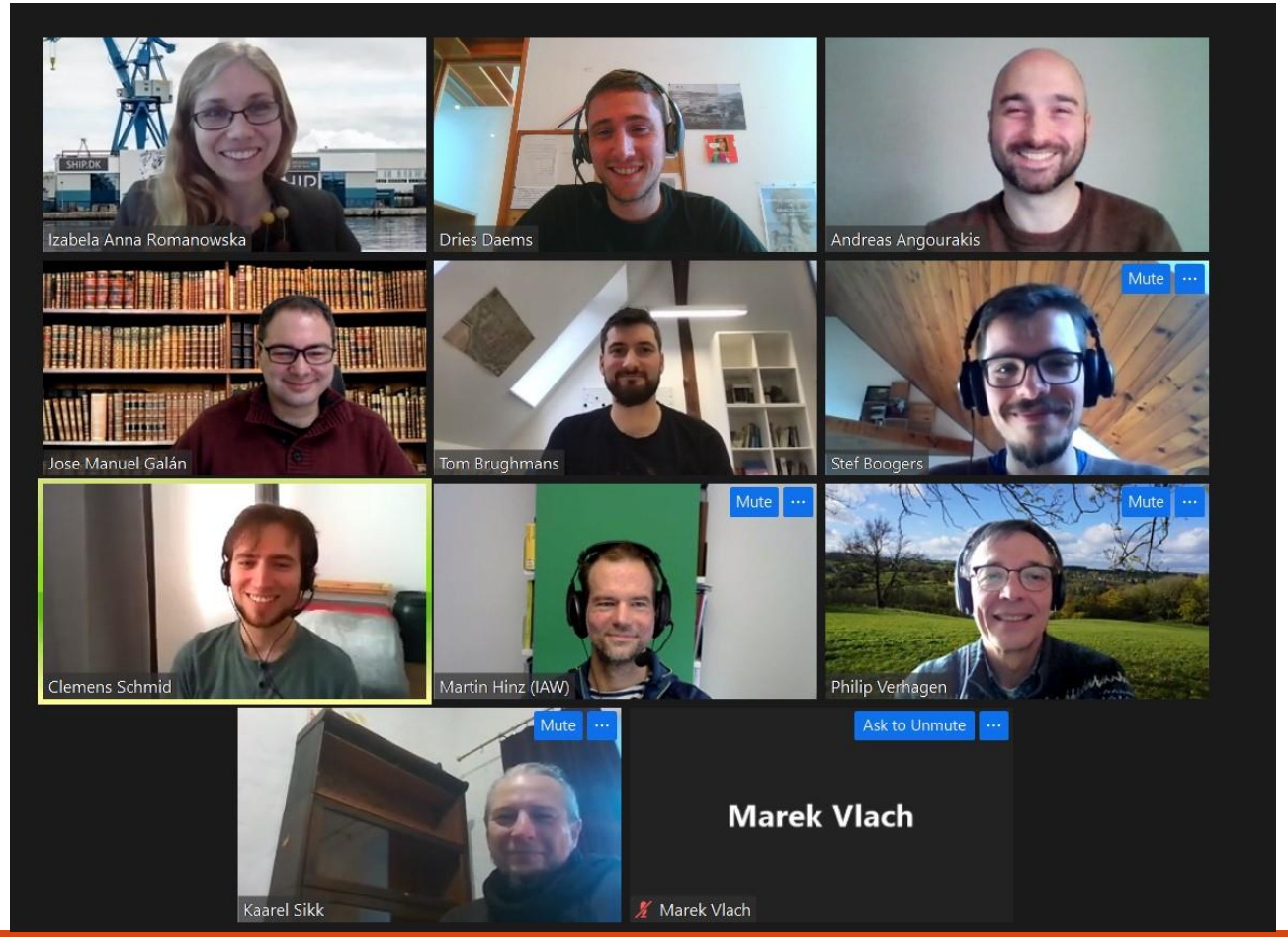
Future: Workshops, summer schools, tutorials, …

- Soon: Leuven 2022

Who are we?

Research units currently active in NASA are:

- Sagalassos Archaeological Research Project (SARP), University of Leuven
- Roman Mediterranean Archaeology Research Unit, Ghent University
- Ghent Centre for Digital Humanities (GhentCDH), Ghent University
- CLUE+, Vrije Universiteit Amsterdam
- Research Centre for the Roman Period and the Migration Period, Institute of Archaeology of the Czech Academy of Sciences, Brno
- Cultures and Environments. Prehistory, Antiquity and Middle Ages (CEPAM), French National Centre for Scientific Research (CNRS), University Côte d'Azur
- Computational and Digital Archaeology Laboratory (CDAL), McDonald Institute for Archaeological Research-Department of Archaeology, University of Cambridge
- Classical Archaeology and Centre for Urban Network Evolutions (UrbNet), Aarhus University
- Aarhus Institute of Advanced Studies (AIAS), Aarhus University
- Analytical Sociology and Institutional Design (GSADI Group), Autònoma University of Barcelona
- Institute for Archaeological Sciences, Departement for Prehistoric Archaeology, Bern University
- Science, The Santa Fe Institute (SFI)
- Institute of Archaeology (IoA), University College London
- GIO - Grupo de Ingeniería de Organización, Universidad de Burgos
- Computational Research on the Ancient Near East (CRANE) Project, University of Toronto
- Water Resources / CEG (WRM Group), Delft University of Technology
- School of Culture and Society and CLIOARCH, Aarhus University
- Faculté des Sciences Humaines, des Sciences de l'Éducation et des Sciences Sociales, University of Luxembourg



Join us!

Website: https://archaeology-abm.github.io/NASA/

Contact executive committee:

- Dries Daems: dries.daems@kuleuven.be
- Philip Verhagen: j.w.h.p.verhagen@vu.nl
- Iza Romanowska: iromanowska@aias.au.dk

Think along: join meetings

Contribute!

NA
S²A

NETWORK FOR
AGENT-BASED MODELLING OF
SOCIO-ECOLOGICAL SYSTEMS
IN ARCHAEOLOGY

Slides available here: https://github.com/driesdaems10/CAA-NL-FL-2021

DR. DRIES DAEMS

MIDDLE EAST TECHNICAL UNIVERSITY (TURKEY)

SAGALASSOS PROJECT (KU LEUVEN, BELGIUM)

DAEMS@METU.EDU.TR | TWITTER: @DRIESDAEMS

HTTPS://WWW.DRIESDAEMS.COM

References

Angourakis, A., Bates, J., Baudouin, J.-P., Giesche, A., Ustunkaya, M.C., Wright, N., Singh, R.N. and Petrie, C.A., 2020. How to `downsize' a complex society: an agent-based modelling approach to assess the resilience of Indus Civilisation settlements to past climate change. *Environmental Research Letters*, 15(11), p.115004. https://doi.org/10.1088/1748-9326/abacf9.

Axtell, R.L., Epstein, J.M., Dean, J.S., Gumerman, G.J., Swedlund, A.C., Harburger, J., Chakravarty, S., Hammond, R., Parker, J. and Parker, M., 2002. Population growth and collapse in a multiagent model of the Kayenta Anasazi in Long House Valley. *Proceedings of the National Academy of Sciences*, 99(suppl 3), pp.7275–7279. https://doi.org/10.1073/pnas.092080799.

Carney, M. and Davies, B., 2020. Agent-Based Modeling, Scientific Reproducibility, and Taphonomy: A Successful Model Implementation Case Study. *Journal of Computer Applications in Archaeology*, 3(1), pp.182–196. https://doi.org/10.5334/jcaa.52.

Carrignon, S., Brughmans, T. and Romanowska, I., 2020. Tableware trade in the Roman East: Exploring cultural and economic transmission with agent-based modelling and approximate Bayesian computation. *PLOS ONE*, 15(11), p.e0240414. https://doi.org/10.1371/journal.pone.0240414.

Chliaoutakis, A. and Chalkiadakis, G., 2020. An Agent-Based Model for Simulating Inter-Settlement Trade in Past Societies. *Journal of Artificial Societies and Social Simulation*, 23(3), p.10.

Cioffi-Revilla, C., Luke, S., Parker, D.C., Rogers, J.D., Fitzhugh, W.W., Honeychurch, W., Fröhlich, B., De Priest, P. and Amartuvshin, C., 2007. Agent-Based Modeling Simulation of Social Adaptation and Long-Term Change in Inner Asia. In: S. Takahashi, D. Sallach and J. Rouchier, eds. *Advancing Social Simulation: The First World Congress*. [online] Tokyo: Springer Japan.pp.189–200. https://doi.org/10.1007/978-4-431-73167-2_18.

Coco, E., Holdaway, S. and Iovita, R., 2020. The effects of secondary recycling on the technological character of lithic assemblages. *Journal of Paleolithic Archaeology*, pp.1–22. https://doi.org/10.1007/s41982-020-00055-4.

Conrad, N.D., Helfmann, L., Zonker, J., Winkelmann, S. and Schütte, C., 2018. Human mobility and innovation spreading in ancient times: a stochastic agent-based simulation approach. *EPJ Data Science*, 7(1), p.24. https://doi.org/10.1140/epjds/s13688-018-0153-9.

Crabtree, S.A., Bocinsky, R.K., Hooper, P.L., Ryan, S.C. and Kohler, T.A., 2017. How To Make A Polity (In The Central Mesa Verde Region). *American Antiquity*, 82(1), pp.71–95. https://doi.org/10.1017/aaq.2016.18.

del Castillo, F., Barceló, J.A., Mameli, L., Miguel, F. and Vila, X., 2014. Modeling Mechanisms of Cultural Diversity and Ethnicity in Hunter–Gatherers. *Journal of Archaeological Method and Theory*, 21(2), pp.364–384. https://doi.org/10.1007/s10816-013-9199-y.

Fort, J., Isern, N., Jerardino, A. and Rondelli, B., 2016. Population Spread and Cultural Transmission in Neolithic Transitions. In: J.A. Barceló and F. Del Castillo, eds. *Simulating Prehistoric and Ancient Worlds*, Computational Social Sciences. [Cham: Springer International Publishing.pp.189–197. https://doi.org/10.1007/978-3-319-31481-5_5.

References

Gravel-Miguel, C. and Wren, C.D., 2018. Agent-based least-cost path analysis and the diffusion of Cantabrian Lower Magdalenian engraved scapulae. *Journal of Archaeological Science*, 99, pp.1–9. https://doi.org/10.1016/j.jas.2018.08.014.

Griffin, A.F. and Stanish, C., 2007. An Agent-based Model of Prehistoric Settlement Patterns and Political Consolidation in the Lake Titicaca Basin of Peru and Bolivia. *Structure and Dynamics*, 2(2).

Heckbert, S., 2013. MayaSim: An Agent-Based Model of the Ancient Maya Social-Ecological System. *Journal of Artificial Societies and Social Simulation*, 16(4), p.11.

Isern, N., Zilhão, J., Fort, J. and Ammerman, A.J., 2017. Modeling the role of voyaging in the coastal spread of the Early Neolithic in the West Mediterranean. *Proceedings of the National Academy of Sciences*, 114(5), pp.897–902. https://doi.org/10.1073/pnas.1613413114.

Janssen, M.A. and Hill, K., 2016. An Agent-Based Model of Resource Distribution on Hunter-Gatherer Foraging Strategies: Clumped Habitats Favor Lower Mobility, but Result in Higher Foraging Returns. In: J.A. Barceló and F. Del Castillo, eds. *Simulating Prehistoric and Ancient Worlds*, Computational Social Sciences. Cham: Springer International Publishing.pp.159–174. https://doi.org/10.1007/978-3-319-31481-5_3.

Janssen, M.A., 2009. Understanding Artificial Anasazi. *Journal of Artificial Societies and Social Simulation*, 12(4), pp.1–13.

Oestmo, S., Janssen, M.A. and Marean, C.W., 2016. Testing Brantingham's Neutral Model: The Effect of Spatial Clustering on Stone Raw Material Procurement. In: J.A. Barceló and F. Del Castillo, eds. *Simulating Prehistoric and Ancient Worlds*, Computational Social Sciences. [online] Cham: Springer International Publishing.pp.175–188. https://doi.org/10.1007/978-3-319-31481-5_4.

Shultz, D.R. and Costopoulos, A., 2019. Modeling environmental variability and network formation among pastoral nomadic households: Implications for the rise of the Mongol Empire. *PLOS ONE*, 14(10), p.e0223677. https://doi.org/10.1371/journal.pone.0223677.

Sikk, K. and Caruso, G., 2020. A spatially explicit agent-based model of central place foraging theory and its explanatory power for hunter-gatherers settlement patterns formation processes. *Adaptive Behavior*, p.1059712320922915. https://doi.org/10.1177/1059712320922915.

Verhagen, P., de Kleijn, M. and Joyce, J., 2021. Different Models, Different Outcomes? A Comparison of Approaches to Land Use Modeling in the Dutch Limes. *Heritage*, 4(3), pp.2081–2104. https://doi.org/10.3390/heritage4030118.

White, A.A., 2013. Subsistence economics, family size, and the emergence of social complexity in hunter–gatherer systems in eastern North America. *Journal of Anthropological Archaeology*, 32(1), pp.122–163. https://doi.org/10.1016/j.jaa.2012.12.003.