Is Winter Coming for Agent-Based Modeling? Challenges and the Risk of a Crisis

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Agent-Based Modeling (ABM) has proven to be a powerful methodology for simulating complex systems, even in cases where the underlying generative mechanisms are not well understood. However, despite its success over the past 25 years, ABM faces critical challenges that must be addressed to ensure its credibility and long-term impact.

One of the primary issues is reproducibility. While sharing code and model specifications can partially mitigate this problem, the increasing complexity of models often makes it difficult to distinguish between genuine emergent behaviors and unintended artifacts. Furthermore, academic incentives rarely encourage rigorous validation, increasing the risk of a reproducibility crisis similar to that observed in other disciplines.

A second major challenge concerns model specification. Despite the existence of formal protocols such as the ODD (Overview, Design concepts, Details) standard, its adoption remains inconsistent. The lack of universally accepted formalization methods, coupled with the significant effort required to fully document a model, further exacerbates reproducibility issues.

Third, the absence of modeling standards in terms of software, programming languages, and frameworks creates fragmentation within the ABM community. While NetLogo has become a de facto standard for certain classes of models, there is no unified methodological framework that ensures consistency across studies.

Lastly, many agent-based models are developed by researchers who lack extensive expertise in the specific methodology, as they apply the methodology only occasionally. This results in suboptimal modeling practices and limits the reliability of findings, ultimately affecting the credibility of the field.

Addressing these challenges is crucial, particularly as ABM scholars seek to inform policymakers and real-world decision-makers, and to maintain credibility into the scientific community. Without stronger methodological foundations and community-wide best practices, the risk is that ABM will lose its credibility as a tool for understanding and shaping complex systems.