Graduate Course:

CSS 645 (001), EVPP 741 (002), GGS 631 (001)

Spatial Agent-based Models of Human-Environment Interactions

Provisional Syllabus

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Office hours: Room 381, Research Hall, Friday 2:00-3:00, 4:30-5:00
or by appointment[1].

[1] Please note between 3pm and 4.30 pm each Friday the CSS Program offers a Seminar Series. All are welcome to attend.

Overview

This course will introduce graduate students in the spatial, environmental, and computational social sciences to the use of agent-based techniques as a means of modeling human-environmental interactions. Emphasis will be placed on spatial processes, the use of spatial identifiers to link socioeconomic and biophysical models, and where possible, links to geographic information and associated technologies. We will cover applications in areas such as agriculture, diseases, forestry, biodiversity, habitat degradation, interactions between human populations and nonhuman species and urban modeling.

The course will combine literature review with some hands-on modeling. When demo versions are available, we will compile and run models as we review articles based on those models. In addition, students will complete a class project where they develop their own models in their areas of interest. Students with no programming background can develop simple models using NetLogo. Students with advanced programming abilities will be encouraged to develop more sophisticated models using packages such as Gama, Repast, MASON, Mesa, etc., or may develop their own spatial agent-based model using the language of their choice.

Course Themes: Since the application of agent-based modeling (ABM) to research on human-environment interactions is still undergoing changes, standard methodology is still in development stages. Therefore, we will focus our discussion on progress to date, and need for further methodological development, in several key areas, including:

- Model ontologies and model communication
- Alternative theoretical models of decision making
- Empirical methods for building agent decision models
- Modeling market interactions
- Modeling institutions
- Modeling cross-scale feedbacks and interactions
- Integration of agent-based modeling and GIS
- Understanding the behavior of complex models
- Model verification and validation.

Prerequisites: Students should have a familiarity with spatial structures and concepts, some background in a social science, and a high level of computing competence. Students should have some familiarity with agent-based modeling and complexity theory, such as would be provided by Introduction to Computational Social Science (CSS 600) or Land-Use Modeling Techniques and Applications (CSS 643). Knowledge of a programming language is helpful but not required. *Additional readings will be suggested for students lacking background in any of these areas*. Generally, no one student has background in all of these areas. Students are encouraged to make stronger contributions in their areas of expertise, and to learn from the expertise of others in their weaker areas.

Course requirements:

Readings: Each week students will be required to read 2-4 readings. Some weeks you have a choice—read carefully.

Short writing assignments (SWA) (30% of grade): Most weeks there will be at least one short writing assignment. Topics will be posted on the class website for that week. Starting in week 5, each student will be required to complete a brief written review of one of the weekly readings, based on the SWA questions on the class web site.

The SWA will be due by 9 AM on the day of the class. Email me (acrooks2@gmu.edu) the short writing assignment and I will post them on the class website under the appropriate week (students are expected to review each others SWA before the class meeting time). **Late short writing assignments will not be accepted**.

Presentations (25% of grade): Students will each be required to give an in-depth review of 2 articles over the course of the semester, starting week 5. Presentation guidelines will be posted on the course website. Please note **presentations are due to me at 9am of the day of the class**. *Note this and in class participation make up to 25% of your of your grade. If you don't understand the paper you may have to read around the subject. Additional references on the class site should help here or Please discuss the paper with me the week beforehand*.

Term project and presentations (45% of grade): Each student will complete a term modeling project in their area of interest and will present the results to the class (students are encouraged to work in groups of two if this option is chosen one grade per group will be given). A minimum of 1000 (max 1500) word abstract/proposal of your project is due in week 4. Please also include (separate to this length requirement) any relevant citations (5-10 citations, probably no more than that). The abstract should tell me:

- What is the research question that you wish to investigate (as someone else puts it, what is the model "for"; not what is the model "of")?
- Why is this question interesting and relevant?
- How will you address the question? (What sort of model, what language, etc.)

The final paper should be a minimum of 6000 words and no more than 8000 words (including citations).

- Papers under or over these limits will lose one quarter of a letter grade per 500 words.
- The paper is expected to be of similar style to that of a journal article (as those reviewed in class including the appropriate referencing style).
- Must utilize and be relevant to material discussed in the class (i.e. must be a spatial agent-based model).
- Clearly describe the model and discuss results.

- In addition to the paper, the model code (in electronic format along with auxiliary material) is also expected so I can run the model when grading the paper.

Students are expected to give a 20-30-minute presentation of their models along with their findings to class at the end of the semester (in a similar style to that of a conference presentation).

The final paper (including model code and data) is due at the end of the semester (email them to acrooks2@gmu.edu). You may also create a web page with animations, model demo, etc. if you like. Late papers will lose one quarter of a letter grade per 24 hours.

Late short writing assignments will not be accepted. You may make up to two SWAs by doubling up for another week, posting a writing on a seminar or conference paper presentation that you attend, or completing another assignment that we both agree on. If you are not able to present a paper of your choice on the assigned day due to an authentic emergency, you will be asked to present another paper later in the semester instead. ("I had to stay late at work" is not an authentic emergency.) Other late work will lose one quarter of a letter grade per day.

Grading: Student's grades will be based on the following:

- 25%: Article presentations.
- 30%: Short writing assignments, and class participation.
- 45%: Term project (10% for initial abstract, 10% for final presentation, 80% for final paper).

Incomplete grades policy: following the university policies, an "Incomplete" grade (IN) may be assigned to a student who is passing a course but who may be unable to complete scheduled course work due to a cause beyond reasonable control. Any requests for an incomplete grade must be submitted **in writing** during the last week of classes, and should indicate the reason for the request. If an IN grade is granted, it is your responsibility to contact the instructor at the end of the semester to make proper arrangements for completing any missing work. For further details on the IN grade please visit: https://registrar.gmu.edu/topics/incomplete/

Below is the grading score I will be using in class

Grading Scale: (points = percentage)

- 95-100 = A+ (Note this is Journal quality work)
- 88-94 = A
- 82-87 = A-
- 76-81 = B+
- 70-75 = B
- 64-69 = B
- 58-63 = C
- <58 = F

Please check before class to ensure that cell phones are turned off.

Academic Integrity

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be cited, using MLA or APA format. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see me.

As in many classes, a number of projects in this class are designed to be completed within your study group. With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product.

Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers on drafts of the work; however, it is not appropriate to give your paper to someone else to revise. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

The re-use of computer models is not acceptable. If one does use code from another model, please ensure the code that is used is accredited to the original model (just as you would do to a reference in a paper). Moreover, the re-use of papers, presentations, etc., from one course in another course is not appropriate. I expect that work that is submitted for this class has been done only for this class.

Disability Statement

If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; http://www.gmu.edu/student/drc/) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Student Support Resources

George Mason University has a number of academic support and other resources to facilitate student success (e.g., Counseling and Psychological Services, Learning Services, University Career Services, the Writing Center, etc.). See http://www.gmu.edu/ for more details.

Class Website

The class website contains all the supplementary material needed for the course. Material for each class including models is given in the assigned week.

Please note that course handouts (lecture slides) will not be available until the day of the class, however core reading material and references will be provided beforehand. I do not expect you to read all the additional references; I provide them purely for a reference resource for topics covered in class.

You should check this website regularly for updates.

Office Hours and Contact Information

I hold office hours (Room 381, Research Hall) every Friday either between 2 to 3pm or 4.30 to 5pm (note between 3 and 4.30 is the CSS Friday Seminar series which you are welcome to attend). I am also available via appointment. Please note if you email me (acrooks2@gmu.edu), I will respond but it might take up to 24 hours and I will not respond to emails over the weekend. **Please note its is George Mason University policy to use GMU assigned emails. If you email me by any other email address I will not respond.**

Reading Assignments

All readings are assigned as preparatory material to the weekly meeting. The reading material for this course consists mostly of required readings and optional recommended readings listed below and detailed for each meeting. The optional readings may or may not be discussed in class, depending on the time available, but is nonetheless included in the interest of depth and completeness.

There is no defined textbook for this class. Articles and chapters are available online or are made available on the course website.

Provisional Weekly Schedule of Topics Along with Compulsory and Suggested Readings

Please note that the topics and their order are subjected to change at the discretion of the instructor, any changes will be announced in class.

Week/ Date	Topic	Reading	Assignment Due
Week 1	**Conceptual Introduction**	Bousquet, F. and Le Page, C. (2004), 'Multi-Agent Simulations and Ecosystem Management: A Review', *Ecological Modelling*, 176(3-4): 313-332. (*Recommended*). Crooks, A.T. and Heppenstall, A.J. (2012), Introduction to Agent-based Modelling, in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), *Agent-based Models of Geographical Systems*, Springer, New York, NY, pp. 85-108. (*Recommended*). Grimm, V. (2008), 'Ecological Models: Individual-Based Models', in Jorgensen, S.E. and Fath, B.D. (eds.), *Encyclopedia of Ecology*, pp. 1959-1968. (**Required**). Janssen, M.A. and Ostrom, E. (2006), 'Governing Social-Ecological Systems', in Tesfatsion, L. and Judd, K.L. (eds.), *Handbook of Computational Economics: Agent-Based Computational Economics*, North-Holland Publishing, Amsterdam, Netherlands, pp. 1465-1509. (*Recommended*). Parker, D.C., Manson, S.M., Janssen, M.A., Hoffmann, M.J. and Deadman, P. (2003), 'Multi-Agent Systems for the Simulation of Land-Use and Land-Cover Change: A Review', *Annals of the Association of American Geographers*, 93(2): 314-337. (**Required**).	None, get started on the readings.
Week 2	**Introduction Continued: Complexity in Human Environment Systems, Pattern Oriented Validation, NetLogo Models & Resources**	Grimm, V., Revilla, E., Berger, U., Jeltsch, F., Mooij, W.M., Railsback, S.F., Thulke, H., Weiner, J., Wiegand, T. and DeAngelis, D.L. (2005), 'Pattern-Oriented Modeling of Agent-Based Complex Systems: Lessons from Ecology', *Science*, 310: 987-991. (**Required**). Manson, S.M., Sun, S. and Bonsal, D. (2012), Agent-Based Modeling and Complexity, in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), Agent-based Models of Geographical Systems, Springer, New York, NY, pp. 125-140.(Recommended). Parker, D.C., Berger, T. and Manson, S.M. (2001), *Proceedings of an International Workshop on Agent-Based Models of Land-Use and Land-Cover Change.* Irvine, CA, Available at http://www.csiss.org/maslucc/ABM-LUCC.htm. (**Required**). Parker, D.C., Hessl, A. and Davis, S.C. (2008), 'Complexity, Land-use Modeling, and the Human Dimension: Fundamental Challenges for Mapping Unknown Outcome Spaces', *Geoforum*, 39(2): 789-804. (Recommended).	List of 4 article presentation choices.
Week 3	**GIS and ABM Tutorial**	Crooks, A.T. and Castle, C. (2012), The Integration of Agent-Based Modelling and Geographical Information for Geospatial Simulation, in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), Agent-based Models of Geographical Systems, Springer, New York, NY, pp. 219-252. (**Required**).	Suggested home work is for those not familiar with NetLogo to work through the tutorials

Week 4	**ABM/GIS Integration. Model Communication /Ontologies. Strategies for Parameterizing Agent Decision Models.**	Abdou, M., Hamill, L. and Gilbert, N. (2011), Designing and Building an Agent-Based Model, in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), *Agent-based Models of Geographical Systems*, Springer, New York, NY, pp. 141-166. (Recommended). Crooks, A.T., Castle, C.J.E. and Batty, M. (2008), 'Key Challenges in Agent-Based Modelling for Geo-spatial Simulation', *Computers, Environment and Urban Systems*, 32(6): 417-430. (**Required**). Polhill, J.G., Parker, D., Brown, D. and Grimm, V. (2008), 'Using the ODD Protocol for Describing Three Agent-Based Social Simulation Models of Land-use Change.' *Journal of Artificial Societies and Social Simulation*, 11(2): 3, Available at http://jasss.soc.surrey.ac.uk/11/2/3.html. (Recommended). Robinson, D.T., Brown, D., Parker, D.C., Schreinemachers, P., Janssen, M.A., Huigen, M., Wittmer, H., Gotts, N., Promburom, P., Irwin, E., Berger, T., Gatzweiler, F. and Barnaud, C. (2007), 'Comparison of Empirical Methods for Building Agent-based Models in Land Use Science', *Journal of Land Use Science*, 2(1): 31–55. (Recommended).	Term paper topic and short abstract (1000 words)
Applications			
Week 5	**Agrarian Societies**	Deadman, P.J., Robinson, D.T., Moran, E. and Brondizio, E. (2004), 'Effects of Colonist Household Structure on Land Use Change in the Amazon Rainforest: An Agent Based Simulation Approach', *Environment and Planning B*, 31(5): 693-709. Kohler, T.A., Kresl, J., Van Wes, Q., Carr, E. and Wilshusen, R.H. (2000), 'Be There Then: A Modeling Approach to Settlement Determinants and Spatial Efficiency Among Late Ancestral Pueblo Populations of the Mesa Verde Region, U.S. Southwest', in Kohler, T.A. and Gumerman, G.J. (eds.), *Dynamics in Human and Primate Societies: Agent-Based Modeling of Social and Spatial Processes*, Oxford University Press, Oxford, UK, pp. 145-178. Ngo, T. A., See, L. M., & Drake, F. (2009). An agent-based approach to simulating the dynamics of shifting cultivation in an upland village in Vietnam. European Journal of GIS and Spatial Analysis, 19 (4), 493–522. Parker, D.C., Entwisle, B., Rindfuss, R., Vanwey, L., Manson, S.M., Moran, E., An, L., Deadman, P.J., Evans, T., Linderman, M., Mussavi Rizi, M.S. and Malanson, G. (2008), 'Case Studies, Cross-site Comparisons, and the Challenge of Generalization: Comparing Agent-based Models of Land-use Change in Frontier Regions', *Journal of Land Use Science*, 3(1): 41-72. (**Required**). Happe, K., Kellermann, K. and Balmann, A. (2006), 'Agent-based Analysis of Agricultural Policies: An illustration of the Agricultural Policy Simulator	Read Parker et al., and 1 of 4 others. Standard SWA on one article.

		AgriPoliS, Its Adaptation, and Behavior', Ecology and Society, 11(1): 49, Available at http://www.ecologyandsociety.org/vol11/iss1/art49/.	
Week 6	**Slums and Urban Poverty**	Roy, D., Lees, M. H., Palavalli, B., Pfeffer, K., & Sloot, M. P. (2014). The Emergence of Slums: A Contemporary view on Simulation Models. Environmental Modelling & Software, 59, 76-90. (**Required**). Augustijn-Beckers, E., Flacke, J. and Retsios, B. (2011), 'Simulating Informal Settlement Growth in Dar es Salaam, Tanzania: An Agent-based Housing Model', *Computers, Environment and Urban Systems*, 35(2): 93-103. Barros, J. (2012), Exploring Urban Dynamics in Latin American Cities Using an Agent-Based Simulation Approach, in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), *Agent-based Models of Geographical Systems*, Springer, New York, NY, pp. 571-590. Patel, A., Crooks, A.T. and Koizumi, N. (2012), Slumulation: an Agent-based Modeling Approach to Slum Formations, *Journal of Artificial Societies and Social Simulation*, 15 (4). Available at http://jasss.soc.surrey.ac.uk/15/4/2.html	Read Roy et al., and 1 of 3 others. Standard SWA on one article.
Spring Break **No Class**			
Week 7	**Urban Models: Overview and Gentrification**	Benenson, I. and Torrens, P.M. (2004), 'Modeling Urban Dynamics with Multiagent Systems', in Benenson, I. and Torrens, P.M. (eds.), *Geosimulation: Automata-Based Modelling of Urban Phenomena*, John Wiley & Sons, London, UK, pp. 153-248. (**Required**). Diappi, L. and Bolchi, P. (2008), 'Smith's Rent gap Theory and Local Real Estate Dynamics: A Multi-agent Model', Computers, *Environment and Urban Systems*, 32(1): 6 - 18. Jackson, J., Forest, B. and Sengupta, R. (2008), 'Agent-Based Simulation of Urban Residential Dynamics and Land Rent Change in a Gentrifying Area of Boston', *Transactions in GIS*, 12(4): 475-491. O'Sullivan, D. (2002), 'Toward Micro-scale Spatial Modeling of Gentrification', *Journal of Geographical Systems*, 4(3): 251-274. Torrens, P.M. and Nara, A. (2007), 'Modelling Gentrification Dynamics: A Hybrid Approach', Computers, Environment and Urban Systems, 31(3): 337-361.	Read Benenson and Torrens (not for SWA) and one other. SWA on any of the others.
Week 8	**Urban Models: Residential Land Markets**	Filatova, T., Parker, D. and van der Veen, A. (2009), 'Agent-Based Urban Land Markets: Agent's Pricing Behavior, Land Prices and Urban Land Use Change', *Journal of Artificial Societies and Social Simulation*,	Read Parker and Filatova. SWA on any of

		12(1), Available at http://jasss.soc.surrey.ac.uk/12/1/3.html. Magliocca, N.R., Safirova, E., McConnell, V., and Walls, M. (2011). An economic agent-based model of coupled housing and land markets (CHALMS). Computers, Environment, and Urban Systems, 35(3): 183-191 Parker, D.C. and Filatova, T. (2008), 'A Conceptual Design for a Bilateral Agent-Based Land Market with Heterogeneous Economic Agents ', *Computers, Environment and Urban Systems*, 32(6). (**Required**). Wise, S. and Crooks, A.T. (2012), Agent Based Modelling and GIS for Community Resource Management: Acequia-based Agriculture, Computers, Environment and Urban Systems, 36(6): 562-572. Torrens, P.M. (2007), A Geographic Automata Model of Residential Mobility, Environment and Planning B, 34(2): 200–222	the others.
Week 9 **No Class.** **Dr. Crooks Out of town. Use the time to work on your model**			
Week 10	**Individual-based models**	Grimm, V. and Railsback, S.F. (2005), 'Introduction', in Grimm, V. and Railsback, S.F. (eds.), *Individual-Based Modeling and Ecology*, Princeton University Press, Princeton, NJ, pp. 3-21. (**Required, not for student presentation**). Hogeweg, P. and Hesper, B. (1983), 'The Ontogeny of the Interaction Structure in Bumble Bee Colonies: A MIRROR Model', *Behavioral Ecology and Sociobiology*, 12(4): 271-283. Mooij, W.M., Bennetts, R.E., Kitchens, W.M. and DeAngelis, D.L. (2002), 'Exploring the Effect of Drought Extent and Interval on the Florida Snail Kite: Interplay Between Spatial and Temporal Scales', *Ecological Modelling*, 149(1-2): 25-39 Railsback, S.F. and Harvey, B.C. (2002), 'Analysis of Habitat Selection Rules using an Individual-based Model', *Ecology*, 83(7): 1817-1830.	Read Grimm and Railsback plus at least 1 other; SWA on Hogeweg or Mooij or Railsback
Week 11	**Mobile Agent Models**	Batty, M. (2003), Agent-Based Pedestrian Modelling, *Centre for Advanced Spatial Analysis (University College London): Working Paper 61*, London, UK. (**Required, not for student presentation**). Batty, M., Desyllas, J. and Duxbury, E. (2003), 'Safety in Numbers? Modelling Crowds and Designing Control for the Notting Hill Carnival', Urban Studies, 40(8): 1573-1590. Gimblett, H.R., Richards, M.T. and Itami, R.M. (2002), 'Simulating Wildland Recreation Use and Conflicting Spatial Interactions using Rule-Driven Intelligent Agents', in Gimblett, H.R. (ed.) *Integrating Geographic Information Systems and Agent-Based*	Read Batty (2003) Ped Mod plus at least 1 other. SWA on 1 other.

		Modelling Techniques for Simulating Social and Ecological Processes, Oxford University Press, Oxford, UK, pp. 211-243. Bennett, D.A. and Tang, W. (2006), 'Modelling Adaptive, Spatially Aware, and Mobile Agents: Elk Migration in Yellowstone', International Journal of Geographical Information Science, 20(9): 1039-1066.	
Week 12	**Disasters and Disease Models**	Hawe, G. I., Coates, G., Wilson, D. T., & Crouch, R. S. (2012). Agent-based simulation for large-scale emergency response: A survey of usage and implementation. ACM Computing Surveys (CSUR), 45(1), 8. (**Required)** Crooks, A.T. and Wise, S. (2013), GIS and Agent-Based models for Humanitarian Assistance, Computers, Environment and Urban Systems, 41: 100-111. Crooks, A.T. and Hailegiorgis, A.B. (2014), An Agent-based Modeling Approach Applied to the Spread of Cholera, Environmental Modelling and Software, 62: 164-177. Epstein J.M., Pankajakshan R., Hammond, R.A. (2011) Combining Computational Fluid Dynamics and Agent-Based Modeling: A New Approach to Evacuation Planning. PLoS ONE 6(5): e20139. doi:10.1371/journal.pone.0020139. Simoes, J. (2012), 'An Agent-Based/Network Approach to Spatial Epidemics', in Heppenstall, A.J., Crooks, A.T., See, L.M. and Batty, M. (eds.), Agent-based Models of Geographical Systems, Springer, New York, NY, pp. 591-610.	Read Howe et al., SWA on 1 other.
Week 13	**Human/non-Human Interactions**	An, L., Linderman, M., Qi, J., Shortridge, A. and Liu, J. (2005), 'Exploring Complexity in a Human–Environment System: An Agent-Based Spatial Model for Multidisciplinary and Multiscale Integration', *Annals of the Association of American Geographers*, 95(1): 54-79. Harper, S.J., Westervelt, J.D. and Trame, A. (2002), 'Management Application of an Agent-Based Model: Control of Cowbirds at the Landscape Scale', in Gimblett, H.R. (ed.) *Integrating Geographic Information Systems and Agent-Based Modelling Techniques for Simulating Social and Ecological Processes*, Oxford University Press, Oxford, UK, pp. 105-123. Linard, C., Poncon, N., Fontenille, D. and Lambin, E.F. (2008), 'A Multi-agent Simulation to Assess the Risk of Malaria Re-emergence in Southern France', *Ecological Modelling*, 220(2): 160-174. Mathevet, R., Bousquet, F., Le Page, C. and Antona, M. (2003), 'Agent-Based Simulations of Interactions Between Duck Population, Farming Decisions and Leasing of Hunting Rights in the Camargue (Southern France)', *Ecological Modelling*, 165(2-3): 107-126.	Read 2 of 4. SWA on any one of the 4.

Week 14	Student Project Presentations		
Week 15	Student Project Presentations		

Note: Recording of any kind (audio, video), reuse of course materials, and further dissemination of the course content is not permitted unless prior written consent of the professor and George Mason University has been given or if recording is part of an approved accommodation plan.